Report of the
Defense Science Board Task Force

on

NATIONAL IMAGERY AND MAPPING AGENCY

April 2000

Office of the Under Secretary of Defense
for Acquisition, Technology & Logistics
Washington, D.C. 20301-3140

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MEMORANDUM FOR UNDER SECRETARY OF DEFENSE (ACQUISITION, TECHNOLOGY & LOGISTICS)

SUBJECT: Final Report of the Defense Science Board Task Force on the National Imagery and Mapping Agency

I am pleased to forward the final report of the Defense Science Board (DSB) Task Force on the National Imagery and Mapping Agency (NIMA). This effort, co-chaired by Dr. Anita Jones and Mr. Peter Marino was formed to review NIMA's objectives and plans and to determine whether the United States will continue to have superior imagery and geospatial information which national and military plans assume. This final report represents the collective view of the Task Force members on this very important topic.

Continued dependency on superior information is a cornerstone of DoD plans for the future. Statements of strategic and tactical military concepts for the future, such as Joint Vision 2010, assume this foundation of information superiority. But the world is changing rapidly. In the past, American information superiority rested largely on the exclusivity of U.S. overhead collection assets. This exclusivity is eroding rapidly, as an increasing number of countries and commercial entities field imaging sensors aboard satellites and aircraft. Timely views of almost any point on earth are readily available for sale, and image resolution increases year by year.

The National Imagery and Mapping Agency (NIMA) has a key role to play in maintaining the information superiority that is critical to both national and military users. Without an effective end-to-end system, information superiority cannot be retained, regardless of the U.S. collection capability. To build and sustain the end-to-end system called Tasking, Processing, Exploitation and Dissemination (TPED), NIMA must become a world-class information delivery organization. It must, in fact, become the functional manager of the imagery and geospatial community just as the National Security Agency is for signals intelligence. It must give more priority to modernization and not permit the pressures of routine operation to dilute and delay modernization. NIMA must become a smaller, elite mission-driven organization.

I endorse all of the Task Force's recommendations and propose you review the Task Force Chairman's letter and report.

Craig I Fields

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DEFENSE SCIENCE
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Memorandum for the Chairman, Defense Science Board

Subject: Final Report of the Defense Science Board Task Force on the National Imagery and Mapping Agency

For decades the United States has had information superiority, i.e. has had a clearer view of unfolding events, than its adversaries. To a great extent that advantage was due to the fact that the United States collected more and better geospatial data (particularly from satellite sensors) than its adversaries. In the future adversaries will gain ready access to such geospatial data. This change is dramatic; it threatens U.S. information superiority.

NIMA, the National Imagery and Mapping Agency, has the mission of ensuring that U.S. forces and U.S. policy makers can operate in an environment of superior imagery and geospatial information. In reviewing NIMA, this Task Force addressed the question of how information superiority can be maintained in a world of proliferating sensors. This Task Force believes that the United States can maintain information superiority in the face of this change. It depends upon four elements: superior (often user-customized) exploitation of information; timely, high velocity delivery of only the needed information; fusion/integration of all relevant intelligence information into a geospatial framework; and "exquisite" (U.S. unique) collection.

NIMA is the functional manager that is responsible for the development of the Tasking, Processing, Exploitation and Dissemination (TPED) system for geospatial information. It is the TPED system that must deliver the superior exploitation, user operated customized tools, information products on demand, fusion of intell products, and high velocity delivery where advantageous. These systems functions, together with routine and exquisite collection, can yield future U.S. information superiority.

It is NIMA that will play the pivotal role in creating TPED. It is NIMA's responsibility to define the strategy, implementation plan, and necessary resources to build this end-to-end system that will deliver geospatial information superiority. To this end, the Task Force recommends a strategy and specific actions. It makes seven major recommendations:

- *Strengthen NIMA's Role as Functional Manager of U.S. Imagery and Geospatial Information.* The Deputy Secretary of Defense and the Director of Central Intelligence (DCI) need to reemphasize NIMA's charter as the executive agency for all geospatial information.

- *Create the Tasking, Processing, Exploitation and Dissemination System.* This Task Force believes unless the TPED end-to-end system as envisioned in this report is built, the United States will not maintain information superiority, regardless of the collection capabilities. The Task Force recommends that the Director of NIMA define and implement the TPED global architecture.
- *Elevate Modernization within the NIMA Organization.* NIMA should hire additional computer, communications, and information engineering experts. The Task Force recommends that the Director of NIMA establish an additional Deputy Director position specifically charged with modernization.
- *Nurture U.S. Commercial Imagery and Geospatial Industry.* The government should nurture—but not subsidize—the emerging domestic industry. NIMA should fully exploit commercial capabilities for both routine production and modernization.
- *Sufficiently Fund All Elements Critical to Imagery and Geospatial Information Superiority.* To develop a system that delivers information advantage, all aspects of the information system must be funded: information accession, processing, exploitation, and dissemination. Today, national and tactical collections are reasonably funded. But, construction of the TPED system and commercial collection and services are not sufficiently funded.
- *Protect and Extend U.S. Geospatial Information Superiority.* On the defensive side, the United States must protect the capability delivered by geospatial information systems, and must prepare to operate with a degraded capability. On the offensive side, the United States should develop a clear understanding of what imagery and geospatial products potential adversaries may access, and what vulnerabilities that creates for coalition and U.S. forces.
- *Evolve NIMA to a Smaller, Elite, Mission-Driven Organization.* NIMA must develop greater expertise in the design and development of complex distributed information systems. It needs to strengthen its deployment and training components. It needs to downsize to complement production outsourcing and at the same time increase the internal systems engineering expertise needed for the future.

We thank the Task Force members and the talented group of government advisors for their hard work and valuable insights. Their dedication reflects their belief in the importance of this challenge to the Department. It is noteworthy that LTG James King, the Director of NIMA, spent a significant amount of time working with this Task Force. We thank him for his active participation.

Anita Jones

Anita Jones, Co-Chair

Peter Marino

Peter Marino, Co-Chair

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The United States has relied on the possession of superior geospatial information in the form of images and maps for the last several decades. Both strategic (national/political) and tactical (military) advantage was derived from information captured by satellite imagery systems such as Corona and its successors. That information was suitably processed into a useful product. This advantage increased during the Cold War and into this decade. In essence, *the United States had a clearer view than its adversaries*. Both our capability to collect images around the globe, and the adversary's lack of such information gave the United States information superiority, and some say information dominance.

The grand envelopment of the "Hail Mary" ground plan in Operation Desert Storm provided a vivid example. If the Iraqi forces had access to overhead imagery apprising them of the deployment of allied forces in preparation for the "Hail Mary" action, that envelopment would not have been as successful. The Iraqi forces would have been positioned differently, and perhaps properly dug in. More importantly, perhaps, the allies might not have attempted the Hail Mary maneuver had there been a possibility that the Iraqi leaders had timely visibility of Allied force movements.

Continued dependency on superior information is predicated for the future. Statements of strategic and tactical military concepts for the future, such as *Joint Vision 2010*, assume this foundation of information superiority. But the world is changing rapidly. In the past, American information superiority rested largely on the exclusivity of U.S. overhead collection assets. This exclusivity is eroding rapidly, as an increasing number of countries and commercial entities are flying imaging sensors aboard satellites and aircraft. Timely views of almost any point on earth are readily for sale, and image resolution increases year by year.

For instance, Russian representatives will accept a geolocation designation and will deliver existing optical imagery with 1.75-meter resolution taken by the SPIN-2 satellite. The French have been selling 10-meter resolution, SPOT satellite, optical imagery in the commercial market for the last decade. An American commercial company has taskable, fairly high-resolution optical satellites on orbit. Other nations have concrete plans for satellite-borne radar as well as multi- and hyper- spectral infrared systems. The tools for sophisticated manipulation of geospatial information are available commercially. History would argue that because a commercial market for imagery and geospatial information is forming, the best tools can be expected to appear in the competitive market place, rather than in government sponsored development projects.

NIMA, the National Imagery and Mapping Agency, has the mission of ensuring that U.S. forces and U.S. policy makers can operate in an environment of superior imagery and geospatial information. This Defense Science Board Task Force was asked to review NIMA's objectives and plans and to determine whether the United States will continue to have this environment of superior imagery and geospatial information which national and military plans assume.

In reviewing NIMA, this Task Force addressed the question of how information superiority can be maintained in a world of proliferating sensors. No longer is collection the dominant basis for geospatial information superiority as it was in the past. If raw images, the tools to manipulate them, and the ability to communicate derived products are available to all, how can the United States achieve information superiority?

This Task Force believes that there is a basis for information superiority. It depends upon four elements:

- Superior (often user-customized) exploitation of information
- Timely, high velocity delivery of only the needed information
- Fusion/integration of all relevant intelligence information into a geospatial framework
- "Exquisite" collection

By "exquisite" collection we mean two things. We assume that there is a base of routine national, commercial, and theater collection, as well as archives of products produced from past collection. Exquisite collection consists of (1) the additional information that can be collected by assets using sensing technology unique to the United States, and (2) time-controlled, directed collection revisits in two circumstances. The first circumstance is those (limited) cases in which near-current (minutes old) images provide new information that gives advantage to a decision-maker. Second are the unexpected (by the adversary) imaging visits that foil camouflage, deception, and attempts at covert action. Unmanned air vehicles are particularly useful for the latter circumstance.

While there are four elements that contribute to the ability of any nation to attain geospatial information superiority tomorrow, the two most important are *superior exploitation* of information and competitively *higher velocity delivery* of actionable information products to decision-makers. In particular the United States can not hope to realize its investment in enhanced collection without a complimentary investment in exploitation and delivery speed.

The primary metric of information superiority is whether decision-makers have the information to make better decisions than adversaries or competitors. If so, they have decision superiority. "Better" is measured in timeliness (including velocity of delivery), accuracy, precision, customization to the decision at hand (elimination of the extraneous), and insight provided. But time is the most important attribute; we must be able to make decisions within the action cycle of an adversary. When the United States had exclusive access to overhead reconnaissance, the elapsed time used to process data and imagery was not as critical, because even aged information had high value. Today, the basis for attaining decision superiority has dramatically changed.

Information superiority will depend critically on having an end-to-end system characterized by the above four elements. Given a user request, this system must be able to tap all relevant archives, and perhaps task national, tactical, or commercial sensors to take a collection action if necessary. It must permit timely processing and exploitation of information fused from any relevant source, including, for example, signals, intelligence and

human intelligence products. The system must be able to deliver information rapidly to the users: national-level decision authorities, tactical commanders, as well as, individuals (e.g. shooters) operating solo in the air, on the ground, or at sea. The system must be configured so those users can manipulate and assimilate such information into their decision-making processes faster than adversaries. This system must be a natural application extension of the basic information systems used for other purposes, i.e. the military analog to the Internet.

It has been widely assumed that to compensate for the widespread availability of imagery, the United States could rely on superior pre- and post-collection processes—*i.e.*, the tasking, processing, exploitation and dissemination (TPED) of imagery products—to sustain U.S. superiority. However, the advance of commercially available technology threatens reliance on TPED as currently envisioned. The only way in which the United States can maintain information superiority is to make better, and especially, faster, use of geospatial information. The nation can then amplify its timeliness advantage by offering the imagery in combination with other sources of intelligence that will not be generally available.

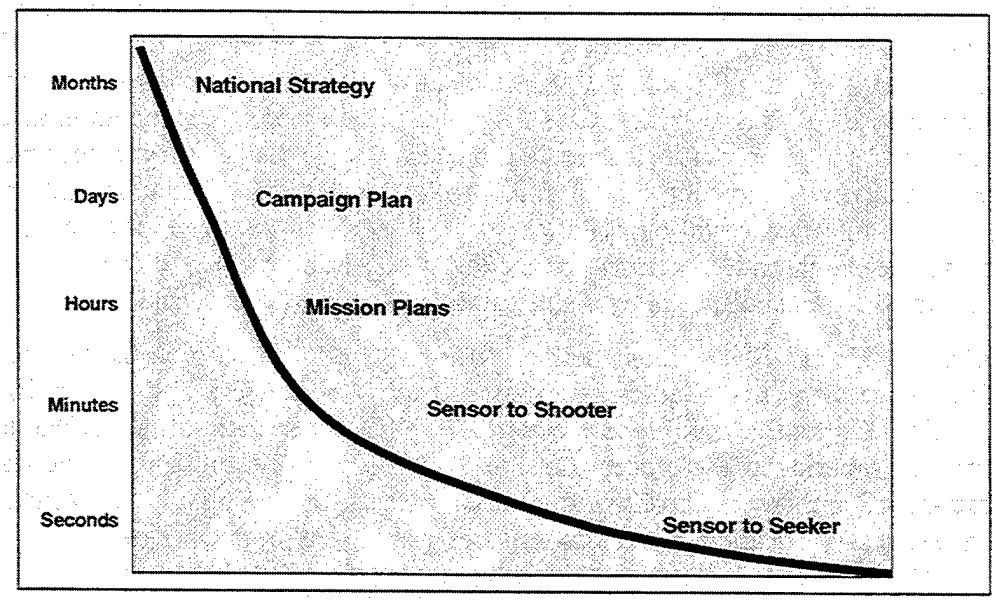

Figure 1: The Need for Speed

This push toward faster turnaround—from the expression of an information need, to fulfillment of that need—will sorely test the intelligence system at large (Figure 1). It is not evident that architectural and operational constructs currently under consideration by NIMA anticipate this challenge, nor is it clear that there exists an adequate dialogue between NIMA, other intelligence agencies, and weapons designers. Without interactive, all-source planning, the United States will not realize the true potential of a responsive, multiple-intelligence-source system.

This Task Force report defines a strategic direction, addresses resources, and recommends management changes to facilitate implementation of our vision for achieving information superiority.

The Task Force believes information superiority rests on several simple principles:

- Stand-alone mapping and imagery products need to be replaced by geospatially referenced imagery and mapping data that are fused into a common framework.
- Geospatially referenced products fom other intelligence sources – such as signals intelligence (SIGINT) and measurements and signature intelligence (MASINT) products – can then be fused into the common geospatial framework. The result is an enhanced common operating picture. Note that the commerical market will not provide signals intelligence, not other certain forms of intelligence. Not only will the United States continue to have these additional intelligence sources, but fused products will leverage one another. Fused products potentially yield more information than a collection of stand-alone products
- The United States Government (USG) should not "compete" with the growing domestic commercial capability, but should build on it, particularly because the commercial capability can be expected to be an important part of the collection mix as well as the best source of exploitation tools. Federal agencies should nurture the emerging, domestic commercial industry by committing to preferentially using U.S. commercial industry for the collection, exploitation, and production that it can provide. It should further encourage the industry to become more technically competent in the future by planning for higher resolution systems and more powerful exploitation tools. Resources should be focused on retaining the "high-end," exquisite collection capabilities unique to the United States and that are needed to maintain information superiority.
- Finally, the United States must define a flexible and robust process for the tasking, processing, exploitation, and dissemination of imagery and geospatial information. Currently, this process is seen by many as sequential. To achieve information superiority, the process must be non-sequential. It must also have an Internet-based architecture from which the consumer can pull data and through fusion and geo-registration, create customized intelligence products.

It is NIMA that will play the pivotal role in creating TPED. Recall that in 1996, the National Photographic Intelligence Center (NPIC), the Defense Mapping Agency (DMA), and other U.S. Government organizations were combined to form the National Imagery and Mapping Agency, the U.S. Government's central organization for imagery and mapping. NIMA is the federal agency tasked to provide imagery and geospatial information to both strategic and military decision-makers. It is NIMA's responsibility to define the strategy, implementation plan, and necessary resources to build this end-to-end system that will deliver geospatial information superiority. It is NIMA's job to set the standards that will facilitate interoperability of information created by others. NIMA should proceed with this job with all deliberate speed. Just as the National Security Agency (NSA) is the undisputed functional manager of signals intelligence, NIMA must act as, and be recognized as the functional manager of imagery and geospatial information.

While many of the authorities necessary for NIMA to assume such a leadership role already exists, there are other necessary authorities that either do not exist, or are not recognized throughout the community. The lack of recognition stems from two primary

causes. First, NIMA is a young organization, others are still reacting to its formation. Secondly, the National Reconnaissance Office (NRO) has been the dominant agency in imagery intelligence. To ensure interoperability, a single functional manager, NIMA, is required. Consequently, the Task Force believes that strengthening the United States' capabilities in imagery and geospatial information must begin by strengthening NIMA's authority. Specifically, the Secretary of Defense (SECDEF) and Director of Central Intelligence (DCI) must re-assert NIMA's role as functional manager for imagery and geospatial information.

With this authority, NIMA should accelerate the development of the architecture for the TPED system. The Secretary of Defense and the Director of Central Intelligence should charge the Director, NIMA, to create the TPED system as rapidly as is feasible.

The Task Force believes that NIMA must make organizational changes to succeed. NIMA must reshape itself. First, and perhaps foremost, the Director of NIMA should elevate the importance of modernization within NIMA by establishing an additional Deputy Director position for modernization. This Deputy Director, who needs to have proven ability to deliver complex information systems, would be responsible for TPED engineering and implementation. A small, but highly qualified, engineering team needs to be put in place under this Deputy Director immediately.

The TPED architecture must be designed to incorporate commercial technologies, services, and products, as they become available. A stronger commercial—government partnership is essential. The emerging U.S. commercial imagery and geospatial industry should be nurtured, not by subsidy, but by early commitments to the timely purchase of products, services, and tools. The commercial imagery and geospatial information industry is fledgling. It is in the interest of the United States that U.S. industry dominates the emerging commercial market. NIMA, and the federal government overall, must take several steps. They must (1) make a commitment to use commercial products and services in a meaningful way, (2) reposition government programs and assets to leverage and complement what industry can do, and (3) adapt policy over time to assure that U.S. industry dominate the commercial imagery and geospatial information market. At the same time, the government intelligence capability can not be compromised.

These actions will lead to a substantial improvement in the delivery of high-quality, time-critical imagery and geospatial information to users. However, alone, this improvement will not guarantee information superiority. As other nations gain increased access to imagery, the United States must develop an understanding of what others can see and know based on openly available information. The United States needs an aggressive information warfare capability.

The balance of this report provides more detail on the current state of U.S. imagery and geospatial information systems and how this Task Force recommends the nation build the end-to-end system that will be required for the future. Building such a system will require more than changes at NIMA. Sustaining information superiority will require a balanced investment in collection (national, military tactical, and commercial) and in TPED, as well as in a research program to seek breakthrough technologies that may restore some of the exclusivity that the nation has enjoyed for decades.

This Task Force believes that it is possible for the nation to sustain the information superiority that it had in the past. The basis for doing so, however, has substantially changed. Creating an end-to-end comprehensive information system that effectively channels the collective assets of the United States to each user depending upon need is a challenge. NIMA must meet this challenge, and must be given the authority, the cooperation of the many stakeholders, and sufficient resources.

1. INTRODUCTION

For the last fifty years, access to more and better information than that available to an adversary has been a cornerstone of both political and military operations. The three following vignettes illustrate the value of superior information.

Consider the grand envelopment of the "Hail Mary" ground plan in Operation Desert Storm. Suppose that during Operation Desert Storm, the Iraqis had had access to imagery and information that would have allowed them to react to the Allied "Hail Mary" troop movement by moving their forces to an effective blocking position. Would the outcome have been different? That will never be known, although the likelihood of minimal allied casualties would have been reduced. More importantly, perhaps, is the possibility that the "Hail Mary" maneuver might not have been considered an option, if the Iraqi leaders had had timely visibility of Allied troop movements.

The value of geospatial information was again illustrated in the Dayton Peace Accords development of November 1995. The United States negotiating team included dedicated cartographers from DMA and the U.S. Army Topographic Engineering Center. The cartographers redrew map boundaries in real time using modern softcopy mapping tools to display proposed boundaries. Territorial implications of different negotiation positions could be clearly determined and displayed so as to clarify positions and advance U.S. arguments.

Advantageous superior information is not limited to mapping and overhead imagery. One final example highlights this point. It involves Operation Overlord, the D-Day invasion on June 6, 1944. The Allied Commanders had superior meteorological information, and were able to accurately predict the brief window in time when the Allies would have favorable weather for military operations in the landing area. The German meteorologists did not have access to the same information, and advised Field Marshall Rommel that no attack would occur. Rommel went to Germany for his wife's birthday, and the German Army partially stood down, contributing to the success of the D-Day invasion.

These three vignettes highlight the significance to U.S. national security of imagery, mapping, and fused information from multiple sources. It is NIMA that has the mission of ensuring that U.S. forces and U.S. policy makers can operate in an environment of superior imagery and geospatial information. NIMA was created in 1996 in a merger of the federal agencies that had previously been responsible for obtaining imagery, generating maps, and fusing information. The objective of the merger was to streamline the generation and delivery of this information.

This Task Force was asked to review NIMA's objectives and capabilities, as well as its plans to meet national and military information needs into the 21st century. Specifically, the Task Force was asked to consider the next generation system for generating and delivering imagery and geospatial information, to assess NIMA as the facilitator of the new system, and to recommend a strategy and specific actions for implementation.[1]

[1] The Terms of Reference for this Task Force is in Appendix B.

2. INFORMATION SUPERIORITY AND THE IMPACT ON NATIONAL SECURITY

The emergence of information systems and communications technology—leading to the information age—has changed the dynamics of national security, as did the mass production of equipment that ushered in the industrial age[2]. Certainly, the ability to gather and correlate information leads to the ability to make better-informed decisions at both the strategic and tactical level. The Task Force believes that the National Imagery and Mapping Agency, as the government agency responsible as the functional manager for imagery and geospatial intelligence, will be at the center of the "information revolution" as it affects individuals and organizations that contribute to national security.

Joint Vision 2010 provides a good framework for thinking about the value of information for military operations. At the macro-level, *Joint Vision 2010* describes the battlefield in the information age, but the concepts described in *Joint Vision 2010* can be extended to the strategic level as well. *Joint Vision 2010* is built around the concept that U.S. tactical commanders will have correlated knowledge concerning the location of both friendly and enemy forces as they are arrayed across the battlefield. If *Joint Vision 2010* comes to fruition, the United States and its allies will have the reconnaissance and surveillance assets to detect and identify objects throughout the battlespace. Further, this knowledge will be extended with the information tools to correlate information about force structure and movement to provide our commanders an estimate of when and where the forces will maneuver. If executed in a timely manner, this capability will provide a decisive advantage in battles. This concept is called dominant maneuver, and is one of the four pillars of *Joint Vision 2010*.[3] As the document states, information superiority and technological innovation enable these four pillars.

The volume of information that can be gathered about a military or political situation is large, and is increasing every year. To be useful, it must be organized in some way. Geography and time are the fundamental parameters. They provide a natural reference framework. The Task Force defines geospatially referenced information as data that is tagged (marked) with location (three-dimensional position in space) and time. In some cases, it is useful to tag information to indicators of movement as well. With a common frame of reference, information of very different types can be combined into a coherent, fused picture that is called the *common operating picture*. Even data that is not a map or an image, that is, does not describe the physical representation of a place, quite frequently relates directly to a geospatial location and a time. For example, all signals emanate from some location at some time. Logistics stockpiles and all force elements are in a precisely defined place at any point in time. So, a geospatial framework is an ideal unifying basis for linking diverse sources of information which describe what is happening in terms of—say—signal emanation; maneuver; the friendly, neutral and enemy order of battle; logistics status and landscape changes that are due to construction.

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2 A discussion of this phenomenon appears in the book *War and Anti-War*, Alvin and Heidi Toffler, 1994. The book describes the information age as the third wave, after the agricultural and industrial age. The Tofflers argue the information age will transform the world, just as the agricultural and industrial ages did.

3 The other pillars are full-dimensional protection, joint logistics, and precision engagement.

The common operating picture can be built up, maintained, and adapted over time. For example, a decision-maker may be concerned with events in a particular area. To build the common operating picture, one may start with a map or a (three-dimensional) topographic terrain grid. Either can form the basis for geospatial registration of other related information. Other types of information can then be draped, or layered, over this grid. For instance, imagery acquired from national technical and tactical reconnaissance systems can be laid over the grided terrain, if that imagery is accurately geospatially referenced. Weather, bathymetry, and geologic survey data can also be inserted. Man-made features can be included and artificial features that are not visible physically, such as demographics and political boundaries, can be added. All manner of attributed data can be inserted. Attributed data is any data that is tagged with location, time, and descriptive information. Attributed data includes (1) a signals intelligence product that traces adversary communications networks; (2) a human intelligence product that describes a formation of enemy armored vehicles, to include location, type of tank, and identification number of the enemy tank; and (3) a moving target indication. When all these disparate data are put together, a fused common operating picture results. All information is geospatially registered, so that any or all of the information relevant to a location (over time) can be displayed, often in combination on the grid. Geospatial reference is therefore a foundation for information superiority, and as such, it should be the fundamental organizing element for both military and national users.

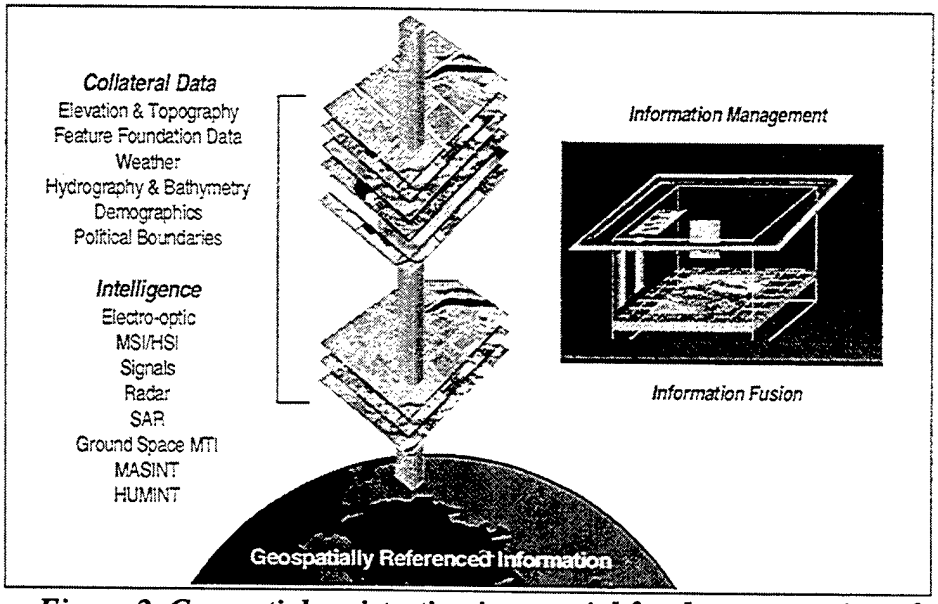

Figure 2. Geospatial registration is essential for the construction of a common operating picture

To construct and maintain a current operating picture and to share it simultaneously with others requires a system that both provides the requisite information, and provides manipulation and displays in response to user command. TPED is also a name for the process of managing, storing and manipulating information from the time that an information product is first processed from raw data through the time that it is manipulated and viewed by the user. TPED is also a name for the underlying information system. This term was used

because it is commonly understood. This Task Force uses the term TPED to mean the *future, end-to-end* system and process that will underpin information superiority. However, one needs to recognize that considerable effort goes into tasking individual collection assets and into the processing of raw data.

TPED is an application. It does not stand alone, or apart. It "rides on" underlying communications, operating systems and other generic information systems. Thus, it must be compatible with them. It provides for *tasking* of information assets that produce geospatially referenced products. Logically, all sources of information should be included if TPED is to be effective and efficient. Sources include databases, archives, and libraries of extant information products. The "high level" tasking in TPED should select among collectors fielded by different organizations—national, tactical, and commercial—if new products are needed.

TPED includes *processing*—the processing of raw data to create intelligence products. TPED involves *exploitation*—the manipulation, and perhaps fusion of data or information from multiple sources to create tailored, more refined, products useful for particular purposes. The end-to-end TPED needs to support users with a wide variety of expertise and intents, from a tactical commander in the theater to an intelligence analyst, expert in reading multi-spectral signatures of camouflage material. As part of exploitation, TPED should offer display and exploitation tools for a wide variety of uses.

Lastly, TPED includes *dissemination*, the timely delivery of products (whether by push or by pull) as well as support for cooperating users who are remote from one another as they simultaneously discuss, mark, and adapt their common operating picture. The fundamental operation envisioned is primarily a demand/pull web-based system. It will be a system that puts the consumer in charge of the data received and intelligence produced. TPED is depicted in Figure 3 as a cycle of these four functions. In fact, it is a highly integrated system. And, it necessarily spans the globe.

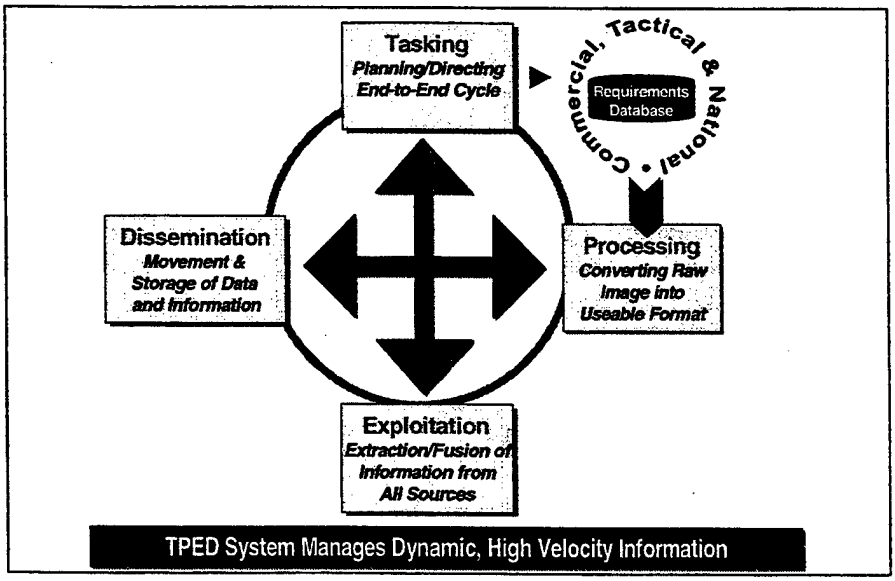

Figure 3. The Tasking, Processing, Exploitation, and Dissemination System

Critical to an effective TPED is velocity—the time needed to obtain, process, and communicate information to decision-makers in a form useful for timely decision-making. To support information superiority, information velocity for the United States (and allies) needs to be faster than the decision cycle of an adversary. It is not good enough to obtain data faster at the sensors than adversaries can if that data is not processed and communicated to the decision-makers in time for them to make the critical decisions. Thus, information velocity refers to the time it takes to get the right information to the decision-makers.

Unfortunately, many see the TPED as a linear, sequential process. If TPED remains linear and sequential, then the United States is unlikely to achieve the data velocity it needs to enable information superiority. Instead of the linear model, Figure 3 describes an integrated, non-sequential TPED process that the Task Force believes is appropriate for meeting Joint Vision 2010 requirements. Many organizations produce products that will be carried in the TPED system. Organizational boundaries and organizational equities cannot be allowed to slow any of the TPED functions unduly.

In the past, the exclusivity of United States reconnaissance systems provided the basis for information superiority. When only one side has reliable reconnaissance systems, information velocity is not so important. Even when information was delivered later than it might have been, the information was of value. For instance, during the Cuban missile crisis, the United States had information superiority due to the U-2 image collection—even though the timeliness of the product delivery to customers was slow by today's standards. Velocity will be a distinguishing characteristic of TPED.

As described earlier, TPED of the future will include a kind of high level tasking that does not exist in the system today. Tasking decisions need to be made at the TPED level in order to make tradeoffs between all possible sources, in competition and in combination. TPED then determines which organization to send a tasking directive. In the past the NRO has been the primary collection organization. When tasking was performed, it was essentially a choice of how to utilize the various national means. This is no longer the case. Because of these changes, the Task Force discussed collection at some length.

COLLECTION—YESTERDAY AND TOMORROW

Our traditional geospatial information superiority resulted, to a great extent, from images collected by overhead national technical means. No longer is exclusive collection a dominant basis for geospatial information superiority. This is a dramatic and rapidly occurring change. The reason is that other nations, as well as commercial entities, are launching satellite sensors with relatively high resolution. Competition to attain information superiority will emphasize other factors—as discussed elsewhere in this report.

The qualities of images, and therefore, of their derived products can be described using the following dimensions:

- Resolution: the measure of the finest detail that is represented by a pixel of image in either spatial or spectral dimensions

- Currency: the timeliness of an image. Currency depends on both orbit and constellation of sensor satellites, or of deployment of theater piloted or unpiloted sensor vehicles
- Mode: images taken in different portions of the electromagnetic spectrum are differently suited to viewing a phenomenon of interest

While exclusivity is disappearing, the United States can compete with others in all of these dimensions. It *will* be a competition. And there are diminishing returns. For a given mission, there is a limit to the resolution that is useful. If the objective is to find and target mobile missile launchers, resolution that makes the radiator cap visible provides little additional advantage. The majority of missions are well served by sensors whose spatial resolution is about one-quarter meter or more. Likewise, currency reaches limits at near-real time.

As sensors—both satellite and airborne—proliferate, the quality of image products both improves and they are broadly available. The sale of foreign imagery started years ago. The French have sold SPOT satellite 10-meter images for over a decade. Any customer can now obtain 1.75 meter optical imagery over a region of interest from the Russian SPIN-2 system.

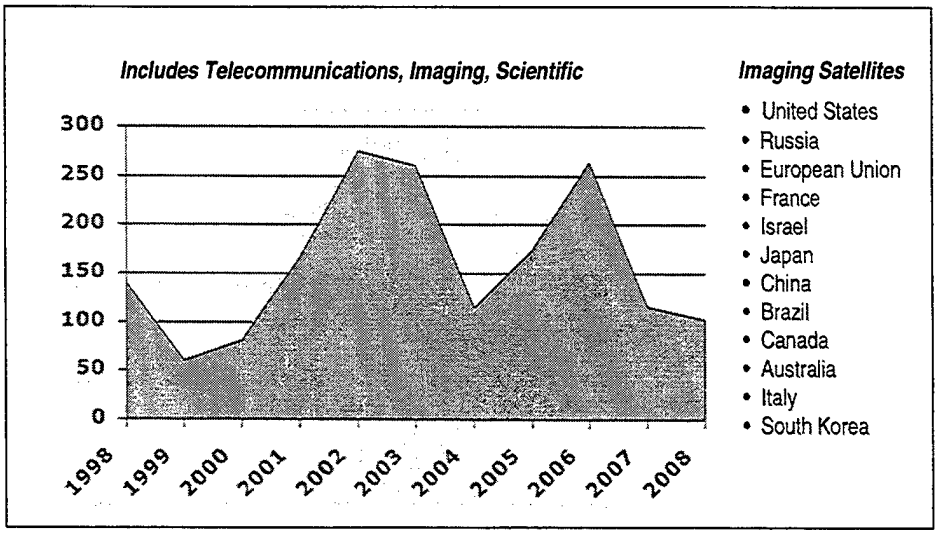

Figure 4. Planned Launches of Space Systems (Communications, Navigation and Imaging)

Figure 4 shows the satellite launches that are planned world-wide for a variety of purposes, including telecommunications and navigation as well as imaging. Numerous nations have imagery satellites. The United States has launched more satellites than any other nation in the world; but compared to the total satellite holdings of the rest of the world, the U.S. fleet is a distinct minority. Figure 5 depicts some of the satellite sensor systems and their expected life between 1995 and 2005. This chart lists international systems as well as some planned U.S. commercial launches. Note that the panchromatic resolutions are in the

single-digit range, with some going below one meter. In addition, multi- and hyper-spectral sensors as well as radar sensors are well represented. Soon, adversaries will be able to buy commercial radar and spectral imagery that provides information at resolutions needed to support both strategic and tactical military objectives.

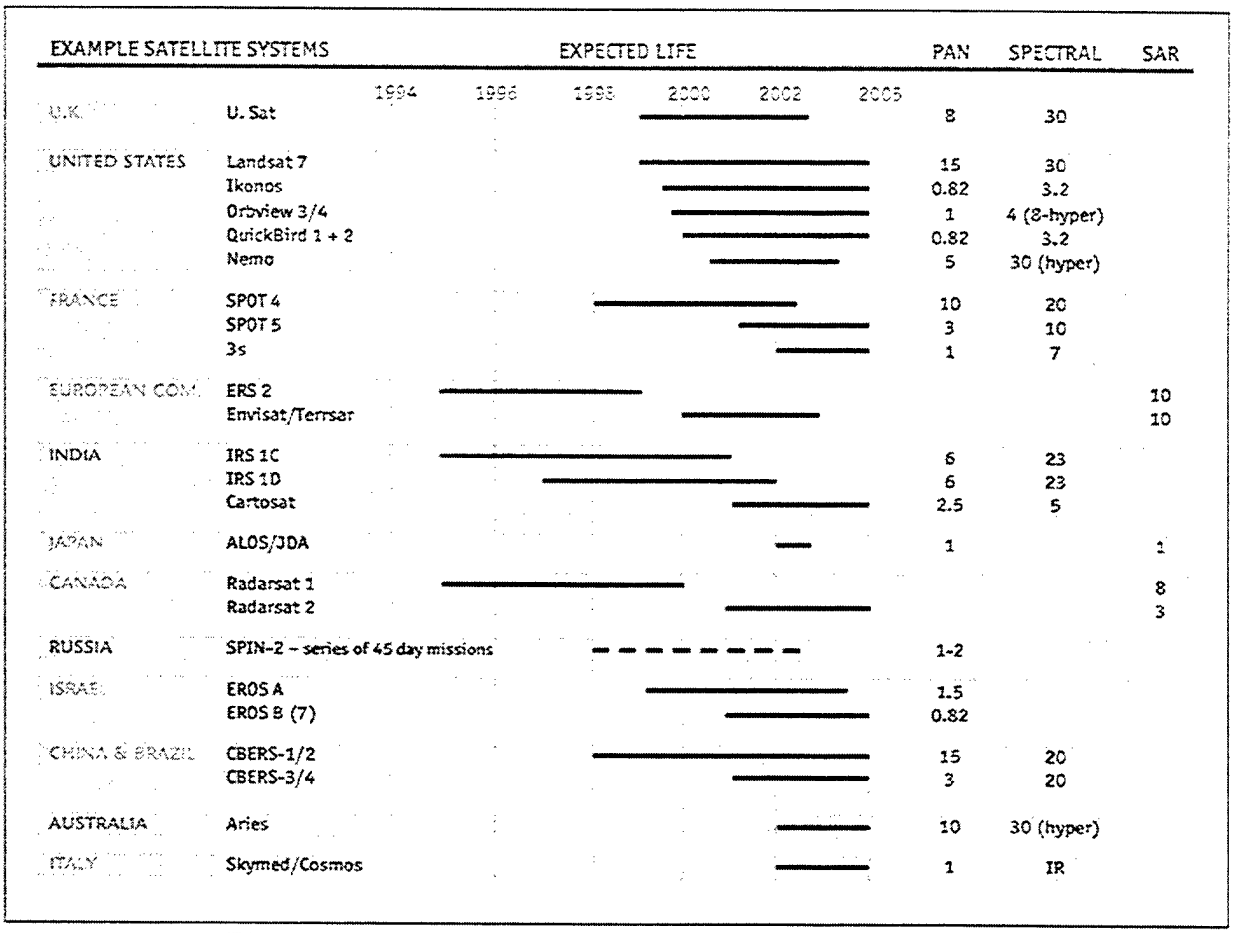

Figure 5. Space-based remote sensing system lifetimes

The Task Force concluded that commercial and international systems could meet many U.S. government needs in terms of image quality if not quantity. Figure 6 shows that the resolution of commercial systems will notably improve between 1999 and 2005 in optical, radar, multi- and hyper-spectral modes. Panchromatic spatial resolution will go below one meter. Likewise, the number of commercial remote sensing satellites will substantially increase in numbers in the same time period. The number of satellites affects the coverage and availability and the response time to re-target. Measured in availability and in resolution, commercial capacity will increase a factor of 5 to 10 times over just the next five years. It is clear to this Task Force that the growing commercial capability should be considered, as an important contributor to meeting United States government needs.

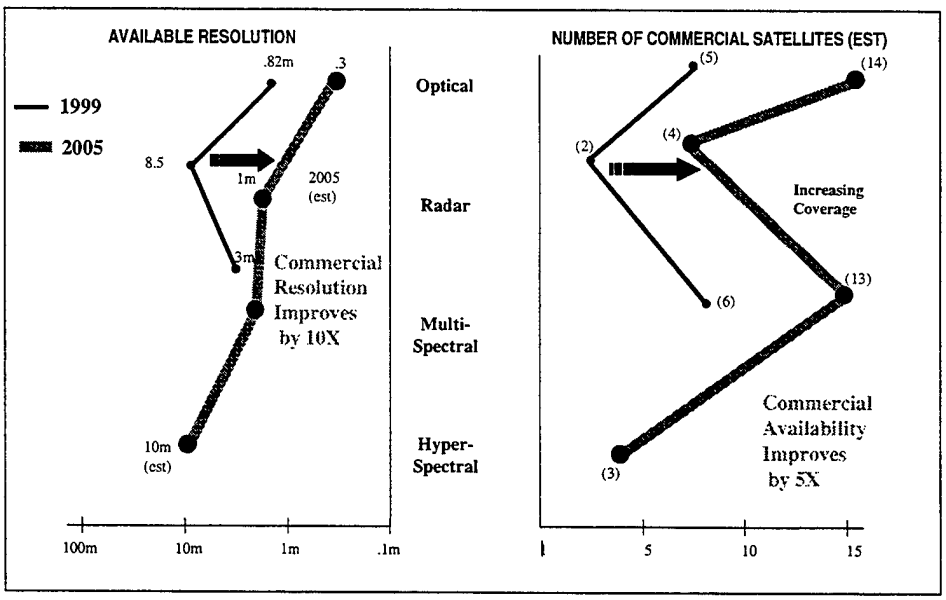

Figure 6. Commercial Capacity to meet U.S. Government Remote Sensing Needs is Increasing

With or without U.S. government purchase of commercial imagery, it is clear that a commercial market for geospatial products is rapidly growing. Applications include:

- Agricultural: monitoring of vegetation health; treatment of a precisely defined crop area with fertilizers, pesticides, or irrigation; counter-narcotics monitoring of coca and poppy fields
- Land management: classification of land use; monitoring glacier growth and melting; geological prospecting; determining the impact of human habitation on coastal waters, swamps, and rivers; determining the impact of natural disasters and fires on timber and other vegetation
- Environmental management: monitoring contamination; monitoring change on a regional or continental scale
- Disaster management: determining the damage and access to areas that have experienced floods, droughts, hurricanes, and wildfires; search and rescue; detecting refugee movements; locating drilling sites for fresh water wells for humanitarian relief
- Infrastructure management: planning new highways and roads, utility installation, pipeline corridor determination, traffic monitoring, population location, monitoring silting of ports and rivers
- Boundary determination: establishing zip code boundaries, county boundaries, tax assessment
- News media reporting: all of the above applications find their way into news reports

It is anticipated that the commercial customer base will be a diverse and growing group with a variety of needs. As in all other markets, there will be an increasing demand for higher quality and lower cost in terms of resolution and phenomenology. Some customers will pay for imaging on demand and the rapid creation of products. Most customers can afford to wait in the tasking queue or until weather permits effective imaging—in trade for a lower price. It is worth noting that the commercial market seems to have less need for distinguishing and tracking moving objects, especially in near real time, an area of particular interest to the DoD. Industry predicts that the market will want resolution to about one-third of a meter. Thus, resolution demands of the military and the commercial market overlap to a very great extent. This Task Force concluded that *there is no doubt that a commercial market for remotely sensed geospatial information products, services, and technologies is growing.* The needs of that market place are in many respects quite similar to those of national security.

This Task Force believes that it is in the interest of the United States to maintain the dominance that it has in this emerging, commercial geospatial information industry. Current dominance derives from the fact that the same companies that build national security satellites and sensors build the commercial sensors, and the United States has a technical lead in that area. Secondly, geospatial information processing to a great degree relies on information technologies where the United States continues to have advantage.

The United States can nurture its commercial industry by outsourcing products and services to it, where capability exists. In particular, if the United States government states that it will purchase products and services, U.S. corporations can approach the venture capital community for the capital necessary to develop sensors and systems. The Task Force does not advocate that any subsidy be given to develop this industry. Rather, NIMA, NRO and other federal agencies that use imagery should allocate an increasing budget for the purchase of commercial products, services, and technology. In addition, national policies restricting technical attributes of commercial vehicles and sensors should be set in such a way that U.S. industry can always stay ahead of the competition. For example, restrictions on sensor resolution should be relaxed as other countries gain technology for a particular level of resolution, or as it becomes evident that commercial providers serve intelligence collection needs better financially or programmatically. Export control of these technologies needs to be undertaken in the context of today's environment – not the environment of the Cold War. Creative partnerships can be advantageous to both government and industry.

While the Task Force advocates nurturing U.S. geospatial industry by depending more upon it, it recognizes that the United States must acquire the best geospatial products that exist in order to achieve information superiority. As a consequence, the United States should continue to buy the best products from both inside or outside the U.S. government. This, in some cases, could mean buying foreign products and services.

EXQUISITE COLLECTION

Other nations and U.S. commercial industry are attaining a capability that substantially overlaps—although not completely—what in the past exclusively belonged to the U.S. intelligence collection community. How and by what means can that community still preserve and grow an advantage? One answer is to focus on what we call *exquisite collection*. Exquisite collection is that which exceeds other nations' collection along with some important dimensions. It is based on:

- Technology unique to the United States
- Timely (near continual, when appropriate, and unexpected) revisits

In the near future, higher spatial resolution will give the United States a unique technical advantage, but not for long, as evidenced by the resolution planned for near-term international launches (see Figure 5).

Hyper- and ultra-spectral technology has potential for yielding exquisite collection for a longer time period. The United States Government can increase its advantage if it successfully develops technology not yet available to other nations or commercial industry.

Timeliness is the second basis for exquisite collection. It is a recognized problem that today's sensor constellations have gaps during which collection against a particular point on the earth cannot be made. And unfortunately, U.S. satellite orbits can be detected and tracked by other nations. Those who wish to hide from imaging sensors track their paths and take action during the gaps. As the duration of the gap is reduced, hiding activity in gaps becomes less feasible and more error-prone. Exquisite collection would eliminate the gaps. There are two ways to do this. First, gaps can be reduced in duration by adding collection during what is now a gap. As will be discussed later, these collections do not necessarily have to be space-based, nor do they have to be high resolution—they merely have to detect (and therefore deny) covert activity. Second, gaps are entirely eliminated if the adversary cannot predict collection. There are complementary technologies that can be used in concert.

For example, imagery can be taken by very high flying aircraft as well unpiloted air vehicles—both large vehicles, such as Global Hawk, and miniature vehicles. Miniature sensors can be introduced surreptitiously by human operatives. It is this combination that can produce sensor configurations that are unpredictable to the adversary. In the future micro-electrical-mechanical systems, there may be the basis for very small sensors mounted on satellites that are so small an adversary cannot track them. Such sensors, if they have suitable resolution and mode, could provide the unexpected revisits that would eliminate the gaps of today—with dramatic cost reductions.

There are increasing opportunities to gain coverage by supplementing U.S. collection with product, which is for sale or trade from other nations. As the total number of satellite sensors around the globe increases, the windows of "no coverage" are shrinking. Future technology should eliminate the "no coverage" problem for many, but not necessarily all, situations.

While this Task Force emphasizes that the United States has lost collection exclusivity, we do see that a leap forward that can be made with exquisite collection. With commercial collectors increasingly able to satisfy many intelligence needs, the USG should focus its talent and resources on gaining a technology advantage that emphasizes exquisite collection.

3. INFORMATION SUPERIORITY AND INFORMATION DOMINANCE

WHAT IS INFORMATION SUPERIORITY? AND WHAT IS INFORMATION DOMINANCE?

In this report the discussion is not focused on all possible kinds of information useful to decision-makers; it does discuss that information which has an attribute of *geospatial registration* —that is, physical location in three dimensions plus time. This definition is not very restrictive. It includes all maps and all images. In addition, it includes information that relates to a specific point on the earth and information that relates to activities located or conducted at some place and for some time. Geospatial registration is the common denominator, the organizing principle, and the basis for fusion of data and products from different sources.

The boundaries of what is included in this definition can be a little fuzzy. It includes geologic characteristics of the earth and some changes through recent time. It includes all intelligence for which the location and time are relevant: man made features such as power stations, underground tunnels, and dock facilities; movement of civilian and military units and equipment; location and loading of grids for communication and for energy; shipping routes on land and sea; and command sites and stockpiles. It includes the capture of changes over time. In the past, the United States only had still pictures, maps and charts; tomorrow, animation of activities that naturally progress through time will characterize the displays provided by U.S. geospatial information systems. Indeed, such animation is beginning to be commonplace.

It does not seem worthwhile to try to fine-tune a definition of what information is included and what is not. What is important is *to assure* that the United States has the ability to *integrate the information* from many sources *based on geospatial location*, when it is useful to do so. Integration permits us to get the benefit of incremental knowledge gained by using additional sources to complement and refine, as well as to corroborate, what was provided by earlier sources.

In summary, geospatial registration is a critical attribute that relates to all physical activities. It provides a framework within which information from many sources can be fused. From the sum of the sources, deductions can be made that are not possible given separate, independent sources. In the past collection was the basis for information superiority. In the future, the basis for information superiority will be fusion of information from a variety of sources, the ability of decision-makers to manipulate the information to meet their needs. As well as the ability to deliver just the information that is needed to where it is needed in a timely way, and the ability to represent an interactive common picture to many users in many locations simultaneously.

So, in this context, what are information superiority and information dominance? Consider analogous terms for air warfare. Air superiority means that if an adversary elects to fly, he will fail to achieve his objective, and most likely be destroyed. Air dominance means that the adversary chooses not to fly at all because of the overwhelming threat of destruction.

Analogously, to have information superiority means to have information that is so much better than that of the adversary that better decisions can be made. Like air superiority, information superiority means that one has an advantageous position from which to act—or to make a decision. Information alone, however, does not guarantee an outcome. Information superiority gives national leaders or a military unit the ability to make better decisions than an adversary. Information superiority cannot, however, assure a viable political or military outcome, if the actual position from which one has to act is not one from which informed decisions and effective action can yield success.

To illustrate information superiority, some examples are provided where the United States did and did not have information superiority. In the Dayton Peace Accord negotiations, the United States had information superiority. When suggestions about boundaries were made, the United States could depict the result of forming that boundary in accurate and visual terms. The implication of decisions was made visual and more understandable. In a situation of its choice, the United States could depict implications with accuracy.

In Desert Storm, the United States did not have information superiority with regard to mobile missile launchers. The Iraqis were able to re-position launchers, shoot, and scoot with some impunity. Today, the nation does not have information superiority in the war on drugs; illegal imports slip across U.S. borders and the jungle processing centers are not identified immediately upon construction. In Kosovo we did not kill as much armor or moving columns as desired. In this case, air dominance did not provide as much of an advantage as it could have had the U.S. force also had information superiority. It is the information superiority that magnifies the effect of air maneuver.

There have been many cases in which the United States had information superiority. And in many cases, the nation acted to make a set of decisions that led to successful outcomes. In other cases, the United States did have information superiority and was unable to make the choices and take the actions that would have been possible with information superiority.

Now, consider the notion of *information dominance*. Dominance is a term that relates to relative positions of entities. When a nation has air dominance (vice just air superiority), the adversary chooses not to fly. To do so would result in *certain* destruction of adversary assets. There may be some times and some places where the term information dominance makes sense. They would be situations in which the adversary elected not to act, because the United States had certain, timely knowledge of the action the adversary might take. Information may contribute to dominance, but typically one party does not dominate another unless it can take overt action—as in air dominance. Information alone does not assure dominance. Indeed, what one might call information dominance is likely to be rare. So, in this task force report, we prefer to use the term information superiority.

The Task Force defines the term *decision superiority* to mean having information superiority, and having it in time to make decisions within an adversary's action cycle. Information superiority as was discussed earlier is the key component to enable decision superiority. And decision superiority contributes to military dominance.

4. AN END-TO-END SYSTEM AND THE ROLE OF NIMA

To achieve information superiority, the nation must evolve an end-to-end system—a highly capable Tasking, Processing, Exploitation and Dissemination system.[4] It must have the following attributes:

- Uses DoD standard communications protocols
- Spans the globe in order to reach all potential users
- Assume that analysts/users will drive the overall system by pulling information, in contrast to today's collector centric system in which information is pushed to them
- Provides user access to relevant geospatial images and image product libraries
- Provides for on-demand tasking of collection assets—national, tactical and commercial—with feedback
- Fuses imagery, imagery intelligence, geospatial, and all-source information products
- Incorporates technology and tools useful to both expert analysts and to decision-makers
- Provides exploitation tools so that field users can tailor their information
- Provides accurate geospatial registration
- Allows insertion of new data and new products from any appropriate site
- Assures timely delivery of products and services, with assured high velocity delivery when it matters
- Assures that information can be injected from any site; in particular, assures that data from tactical assets can be incorporated into archives
- Tags products with a pedigree so that users can determine what level of data integrity is assured
- Assures suitable interoperability with systems that support operations
- Supports a common (interactive) operating picture shared by users at multiple sites
- Supports computers as users by providing timely insertion of information into precision weapons and a variety of simulations (training, engineering, and analytic)

[4] The Task Force uses the term TPED to mean a far more capable geospatial information system than exists today. We decided that we would communicate to the intended audience more effective by using an existing term, rather than coining a new one. The implementation of TPED is in the context of a larger USIGS system.

Such an end-to-end system should enable *superior exploitation* products and the tools for users to customize information for decisions makers and provide *high velocity information delivery* between any two points in the system. Some intelligence data is only of local interest, say at echelons below corps. However, the end-to-end system must have the capability to transfer data globally to support those cases when it is appropriate. *The objective is to deliver quality information so that the United States can make decisions inside the action cycle of the adversary.* The measure of success is whether US decision-makers have superior information in time to make better quality decisions.

The TPED system must meet many challenges. The military and diplomatic environments of TPED users are complex and involve diverse issues from nuclear proliferation to peacekeeping. The demands on TPED have become more diverse since the Cold War when threats and scenarios were more clearly defined and refined. Needs cannot always be anticipated with pre-formatted products that are responsive to a prior set of threats and scenarios. Military users today have a wider diversity of missions; they need a wider variety of products than in the past. This leads to an increased need for customization. Users have varying degrees of skill in accessing information products and customizing them with TPED exploitation tools. The envisioned TPED is expected to simultaneously provide a common operating picture to a distributed set of interacting users. The end-to-end TPED system must deliver considerably more than today's systems, and it must be more robust.

The timelines for delivering information are more stringent. The TPED system of the future should be delivering products to different users under different assumptions such as priority of a request, bandwidth, and loading of communication lines, processing capacity and storage capacity at each involved site. The architecture of TPED needs to provide support for the very short timelines for selected missions. For example, there will be situations in which data from a sensor needs to be delivered very rapidly (and therefore in a relatively raw form) directly to the human (e.g. a shooter) or system (e.g. a simulation of that shooter or the control system of the shooter). Nothing in the TPED architecture should unduly slow delivery. Similarly, if a commercial satellite sensor company contracts to permit re-tasking of a sensor—say 15 minutes before it comes over the horizon—TPED must support issuance of (very high priority) requests in that time window.

DoD has put significant effort into modeling and simulation and into warfighting experimentation to craft tactics, techniques, and procedures for 21st century military operations. Training, exercises, and rehearsal for combat employment of precision capabilities and precision weapons require geospatially-registered information. Today, more often than not, contractor-unique—that is proprietary—databases are used. In contrast, interoperable data sources must become the norm.

Tactical sensors and products customized in the theater will have an increased role to play in the future TPED system. Theater products may be of interest to analysts and decision-makers. Which theater data should be fed back for processing and archiving? The higher premium on rapid dissemination means that the policies and procedures controlling product dissemination from the field need to be thought out. Direct feed of sensor data to a shooter who is far removed needs to be made routine. Appendix E discusses these theater issues. This Task Force does not make recommendations in this area, but determined that it is an important issue.

Another challenge to TPED of the future is the dramatic increase in volume of data and information products that must be handled. The predominant increase will come from increased number of sensors and their higher resolution. Better computational techniques for processing sensor data and for determining what should trigger the cueing of an analyst to inspect part of an image are needed. It is a given that not all-raw data will be inspected manually by analysts. TPED must include around-the-clock routine processing of data with the intent of deriving useful information. This processing must support then-current priorities. Correlation of data from different sources may reduce false alarms, and improve the predictive ability of automated processes for cueing analysts.

In addition, TPED needs to be able to tap a heterogeneous set of archives, including those of National Aeronautical and Space Agency (NASA), the U.S. Geological Survey (USGS), commercial and international holdings, as well as the repositories maintained by NIMA. It is a daunting engineering challenge to manage the access to diverse repositories as well as to control the movement of data including buffering, duplicate storage for reliability, and staging of masses of information that is to be sent between archives or between the Continental United States (CONUS) and a theater. Managing timely data delivery in case of degraded capability due to information warfare adds to the challenge.

Information superiority will require on-demand delivery of information to all levels of command. Commercial progress will drive cost down. Nevertheless, user appetite can be near boundless. Reliance on commercial communications is a fact today and will increase. Some sort of market-based rationing model is needed. The minimum essential communications capability must be assured. In addition, its vulnerability must be acceptably low.

Tasking in the future TPED will need to be defined at two levels, strategic and tactical. The term tactical tasking was used to mean direct control of a collection asset. So, NSA provides tactical tasking for the signals collection assets and NIMA tasks the "national technical means." Theater commanders task theater aircraft and UAVs. Commercial companies tactically task their collection assets. Tactical tasking as described here is routinely performed today.

In addition, the future TPED needs to provide for *strategic tasking*. It needs to make tradeoffs between the various sources of new collection that are available in a timely way to meet a given request. It needs to choose between using national means, theater assets, or a commercial satellite. Strategic tasking makes tradeoffs between the assets of different organizations—the several owners of collection assets. Tradeoffs between different kinds of sensors must be made at a level that is outside of the collector organization.

In the current geospatial and imagery system, there is a tacit assumption that there are producers and there are consumers. It further assumes that producers are in relatively few locations (especially in comparison with users). The future TPED system must accommodate production, or at least limited exploitation, at almost any location. Users will customize products and want to share them with others, or even send them to a TPED repository. In the future, tactical data (which is increasingly becoming geospatially referenced) will be fed back for archiving. Theater sensors may need to deliver data directly to shooters, or to simulations, in order to maintain needed reaction times. The distinction between producer and consumer will become blurred. TPED must be a distributed end-to-end system; it cannot

be sequential. Just as with the Internet, any user may be a producer by just adding value to a product.

Another challenge to TPED is the increased need for cross-correlation and fusing of information from multiple sources. The end-to-end system must be capable of correlating seemingly independent events in time and space. The system should include the capacity to assist the decision-maker in performing predictive analyses by leading that decision-maker to ask the right questions, or by noting that there is additional information available. For example, once a military decision-maker has selected a road or a port, this could be as simple as searching for all known, current geographic data concerning the designated area. The search would include relevant SIGINT, MASINT, and other valuable intelligence information. The related request could be as far-reaching as searching for all known civilian data, once an area or time is identified as a potential combat zone.

Continuity of operations is also important. A new end-to-end system cannot be built at the expense of the smooth running of the current "system." The new TPED must be introduced in such a way that it does not cause unacceptable intelligence lapses.

Many products that will be fused and disseminated in the context of TPED will be built by organizations other than NIMA. For example, NSA is responsible for the accuracy and completeness of the SIGINT products. The packaging or format of those products may need to change because of desired ability to fuse them or display them in concert with geospatial products. It is critical that the interface standards and data formats be agreed upon early and introduced in a disciplined manner. Standards will include communication standards, data and product format standards, tool interface standards, and standards for the preparation and tagging of products with integrity, watermark, or pedigree descriptions. The TPED system must provide a transition path for routine introduction of new technologies and the evolution of standards. The Task Force believes NIMA needs to be the initiating party in setting interface standards.

One can ask how users, themselves, need to adapt for the TPED system of the future to be most effective. Essentially, users will "pull" information into their decision processes and users will tailor their own products. If users are to be more in the forefront of intelligence creation, then it is natural to ask if users should take more responsibility, and consequently be held more accountable, for the intelligence that they use. Appendix F considers the geographic CINC as a receiver and a generator of intelligence. It probes the questions of a CINC should be held more accountable for the intelligence he employs.

We have just listed a lengthy set of challenges that must be met in order to build the kind of TPED system envisioned by this Task Force. However, the Task Force believes that today's technology is sufficient to meet these challenges, as well as to provide a new basis for achieving information superiority. Most of the TPED system envisioned here would have functional properties that are not present in today's geospatial information systems.

It is crucial that an overall detailed architecture be defined for the future TPED. An architecture provides the principles that give a complex system its structure and integrity. Incrementally adapting an existing system to the new TPED is not likely to be successful. Without a clear vision of the desired system in the form of a set of architectural properties, it will be impossible. For example, the notion of high velocity information delivery needs to be defined. It is complex because the TPED system will incorporate communications media that

operate with different performance and functional characteristics. Different users will have different communication network configurations, redundant paths, and bandwidth speeds. A proper TPED architecture would ensure that no undue speed and capacity bottlenecks are encountered.

The future TPED system needs to have a notion of priority that affects how functions are performed over a set of distributed components. It should be possible to make statements about how requests of a particular priority will be handled end-to-end, and to predict the parameters that characterize the responsiveness of TPED under different requests, different operating conditions, and different command decisions regarding priorities.

The Task Force does not believe that there are technology impediments to the creation of TPED; instead, technology offers opportunities for continued enhancement over time. The architecture must provide for the influx of new technology into the system over time. This is particularly true for exploitation, fusing and display.

For example, streaming video presents an entirely new analytic opportunity and challenge. It should be possible to perform dynamic change analysis that, while far more demanding than static image analysis, could yield new information and insights. Similarly future operations will likely include video sensors operating at frame rates geared to human visual processing. Video technology needs to be developed and exercised within the context of TPED.

THE ROLE OF NIMA

NIMA is the organization charged with the mission of ensuring that U.S. forces and policy makers can operate in an environment of superior imagery, imagery intelligence, and geospatial information. NIMA is the organization charged with creating TPED.

Today, the basis for overall information superiority relies particularly strongly on NIMA products and systems because the geospatial framework (grounded in three dimensions and time) is the single, natural framework that can serve as a basis for fusion of all information. In the past imagery-derived products was one among many kinds of intelligence products. Today, accurate geospatial registration provides the framework for merging intelligence products of all kinds to yield the common operating picture.

So, while NIMA's mission has not changed since its establishment, the criticality of that mission, and therefore NIMA's prominence, has changed. Because information technology has become dramatically more useful and affordable, the way in which NIMA needs to implement its mission has changed; and that raises the question of whether NIMA is structured and staffed to be successful at this core mission.

Today, four years after its formation, NIMA remains a child of the agencies that preceded it. It is mainly a production agency that specializes in delivering standardized, pre-formatted information in the form of maps, imagery, or a combination of both to users in hard copy form and digitally. NIMA must continue to create the products that users require today. In parallel, NIMA must refocus part of its organization on creating the architecture for TPED and overseeing its development. That will require a significant enhancement of information systems engineering skills within NIMA. The Director of NIMA must accept this challenge to forge a new agency that truly has the talent to be the world center of technical excellence for geospatial information systems.

Because TPED will define the framework for the fusion of all sources of intelligence products, NIMA needs to define the procedures, the protocols, and the standards, including data and dictionary formats, in order to guarantee interoperability at electronic speeds. NIMA will not generate all the data products in the system. It must be possible to link *on demand* to the relevant data and product providers, such as CIA, NRO, Defense Intelligence Agency (DIA), NSA, and the Central MASINT Office. NIMA must develop close working relationships with these other intelligence data and product providers.

The procedures and standards that support interoperability need to be agreed upon not just within the intelligence and the military communities, but with civilian data providers such as NASA, USGS, National Oceanic and Atmospheric Administration (NOAA), and the commercial industry as well. NIMA should consider active participation in NASA remote sensing programs to motivate rationalization, interoperability and collaboration. NIMA should establish interagency arrangements with the USGS for the procurement of geospatial and imagery services on an as-needed basis.

The high degree of integration and interoperability that an end-to-end system requires will appear to threaten the equities of some other agencies. It must be made absolutely clear to all that NIMA has the executive responsibility for the TPED system. Other agencies need to work with NIMA to ensure interoperability. This Task Force is not advocating that NIMA take on the mission of any other agency—but rather that NIMA have the clout to bring other communities to accept the architecture and the standards necessary to build an integrated TPED system. Realistically, NIMA must have greater visibility into the total investments being made in related areas. To gain insight into all related activities, the Director of NIMA should conduct a budget review and recommend adequacy of expenditures across Defense and Intelligence, including Service tactical collection and exploitation, and all related expenditures under the purview of the Community Management Staff and the Assistant Secretary of Defense for Command, Control, Communications and Intelligence, ASD(C3I), offices. This review needs to be more than perfunctory.

Geospatial information is used in models and simulations for training, exercises, rehearsal, analysis, engineering, and testing. NIMA should participate in setting modeling and simulation standards for imagery and geospatial information interoperability, and require its use.

NIMA should also assume the role of authenticator for imagery and geospatial products. It should develop standards for the metadata tags that all products need to carry to describe the product's pedigree, as well as the standards and the tools by which products can be authenticated. NIMA should not become the enforcer, but should set the standards by which the broader community can exercise more or less cautiousness and quality control as suits their objectives.

Because users are exploiters, NIMA must work more closely with the users. Users did report to the Task Force that NIMA has performed well in its liaison work with the CINCs and the Services and in its deployments to selected theaters during crises. Adequate support to users is critical. Appropriate numbers of NIMA personnel need to be assigned to work in situ on a recurring basis. The cryptologic support teams that are fielded by NSA provide a good model of how to relate with the customer, especially in a crisis. NIMA must deploy experts to remote locations in support of its systems and participate in regular training

exercises to ensure training effectiveness and to prepare the NIMA personnel for field assignment.

NRO is the "captive" U.S. government agent for satellite collection. NIMA is under-represented at NRO, and vice versa. This should change so that the concepts of operations for the two organizations are harmonized, and the execution of the Future Imagery Architecture and TPED converge. The establishment of NIMA/NRO mission partner is an important step in the right direction.

The combination of demands for higher-skilled information and systems engineers and field personnel will require a significant upgrade in the overall technical and operational expertise of NIMA. One way to strengthen the technical competence of the organization is to augment the current research and development program with a shared research program with Defense Advanced Research Projects Agency (DARPA). Projects should seek breakthrough technology that could be injected into TPED at a later date.

Today, NIMA has two primary missions: operations and modernization. It cannot fail at either mission. Currently, these two missions are co-mingled within the same overall organization. As a result, the modernization efforts have trouble competing with day-to-day operations, which receive greater support from today's users, both military and national. NIMA may have to segregate modernization organizationally in order for it to receive appropriate priority and to obtain the appropriate technical and managerial talents needed to design and build a modern end-to-end information system.

NIMA needs to continue its role of providing training and education in the use and the usefulness of geospatial information to professionals in the intelligence community, in the warfighting community and in the national strategy community. NIMA should also actively market TPED and its products, services and exploitation tools to users at all levels of command. Further, NIMA needs to adjust its workforce as part of a balanced strategic plan to fully exploit the extant and evolving commercial capabilities for modernization and production. NIMA should be able to take advantage of commercially available training so they can focus their training efforts on more unique needs.

NIMA should aggressively outsource production. NIMA has certified that industry can produce certain kinds of products. The government should rely on, not compete with, the private sector and instead maintain in-house, high-end expertise to help drive new techniques for state-of-the-art production.

In order for NIMA to assume the roles outlined above, sufficient resources must also be made available for the development and life cycle support of TPED. Unfortunately, today the geospatial information budgets are greatly out of balance. Tactical and national collection are strongly funded. TPED development and commercial collection and exploitation are not appropriately funded. Today's investment for the Future Imagery Architecture (collectors) is roughly in the range of several billion over the Future Years Defense Program (FYDP). Tactical collection appears to be reasonably supported by all military departments, although it proved to be too difficult for this Task Force to estimate the size of that budget.

When this Task Force began its work, the TPED development budget was roughly $250 million over the FYDP. In the President's budget for 2001, the TPED development budget has risen to about $1.5 billion. The Task Force applauds this increase, but believes that

TPED development will cost considerably more – roughly $3 billion over the FYDP. It is not yet in balance with the FIA budget. Likewise, the budget for commercial collection is at too low a level—about $400 million across the FYDP. A more balanced budget is required. As depicted in Figure 7, this Task Force sees the three types of collection (national, tactical, and commercial) as the three legs of a stool. The stool needs to have a firm seat—the TPED systems—if it is to support the users. All elements need to be appropriately funded.

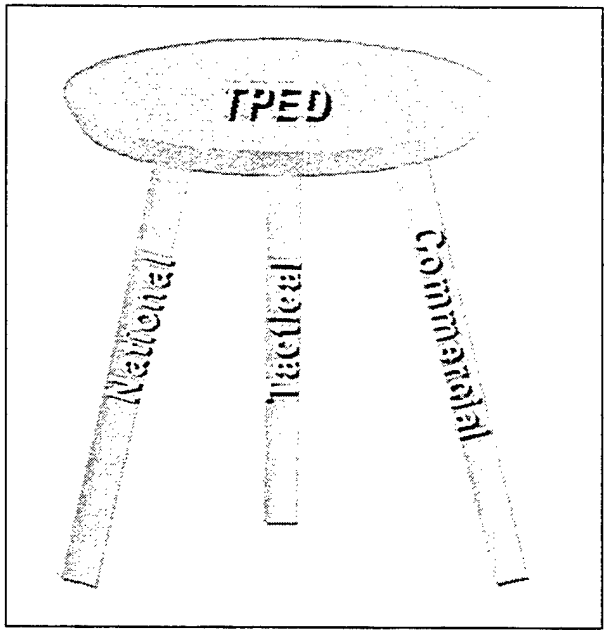

Figure 7. A Balanced Investment in Collection Vice Processing, Exploitation and Dissemination is Required

In summary, in order for the nation to achieve information superiority in the coming decades, NIMA must be a superior agency that:

- Is the functional manager of the imagery and geospatial community
- Develops and implements an effective architecture, protocols, and standards for TPED
- Has sufficient budget and budget oversight to accomplish its mission
- Gives priority to building the system of the future without being dragged into compromises that optimize legacy systems
- Continues to serve the current needs of the customers
- Becomes a smaller, more elite, more technically competent and more mission-driven organization

5. RECOMMENDATIONS

The Task Force was asked to recommend a strategy and specific actions. It makes seven major recommendations.

RECOMMENDATION 1: Strengthen NIMA's Role as Functional Manager of U.S. Imagery and Geospatial Information

While the near monopoly in overhead collection capability is ending, the United States can still retain a substantial, perhaps decisive, advantage in strategic and tactical battlespace awareness. To assure continued superiority of geospatial and imagery information, the most critical objective is to design and construct the TPED system in the form envisioned in this report. NIMA is the organization that should build TPED. The Deputy Secretary of Defense and the Director of Central Intelligence need to reemphasize NIMA's charter as the executive agency for all geospatial information, much as NSA is the executive agency for all SIGINT information. Specifically, the following actions should be taken:

- DepSecDef and DCI should charge the Director of NIMA to:
  - Act as the single functional manager for imagery and geospatial information
  - Define the future TPED architecture, products, and services
  - Determine how to authenticate products and ensure that product quality is accessible to users
  - Develop and acquire tasking capability to trade off between, and task in concert, commercial and government collectors with priorities to be set as at present
  - Establish a technical program seeking breakthrough technology, teamed with the Defense Advanced Research Projects Agency
  - Train and educate professionals, including warfighters, in the use and usefulness of geospatial information
- The Director of NIMA should conduct an annual budget review and build and execute a "Consolidated Imagery and Geospatial Program" (CI&GP) for FY 2001 across Defense and Intelligence
  - Services should identify tactical collection and exploitation expenditures
  - As a one-time effort, the Community Management Staff and the ASD (C3I) should identify all expenditure that are candidates for this program
  - Based on this review, NIMA should recommend to ASD (C3I) whether the expenditures are adequate
- The Director of NIMA should report to Deputy Secretary of Defense and the DCI within one month with specific actions needed to enable NIMA to perform the role of functional manager for imagery and geospatial information

RECOMMENDATION 2: The DepSecDef and DCI Should Charge the Director of NIMA to Create the Tasking, Processing, Exploitation and Dissemination System

This Task Force believes that unless the TPED end-to-end system as envisioned in this report is built, the United States will not maintain information superiority, regardless of the collection capabilities planned for the Future Imagery Architecture and for Unpiloted Air Vehicles. The Task Force recommends that the Director of NIMA should define and implement a global architecture for TPED that will ensure:

- Integration and geospatial registration of appropriate products from multiple INTs
- Sufficient commercial bandwidth and local and remote data storage
- Availability of "best of breed" tools for user exploitation of information
- Agile tasking that takes advantage of commercial as well as national collection assets
- Incorporation of information from tactical assets into archives
- High-velocity (timely) product delivery
- Use of commercial capability wherever it is available

RECOMMENDATION 3: Elevate Modernization within the NIMA Organization

NIMA must strengthen its capability to define and build information systems. NIMA should hire additional computer, communications, and information engineering experts. The Task Force recommends that the Director of NIMA establish an additional Deputy Director position specifically charged with modernization. This Deputy Director should have successfully managed and delivered complex information systems prior to arrival at NIMA. That individual should have a strong reputation within the broader information technology community as well as the NIMA community. This Deputy Director should then be given authority and responsibility to

- Build a strong system engineering capability within a new Directorate and make this a "core competency" of the agency
- Develop a cadre of skilled senior acquisition personnel
- Partner with DARPA and other agencies to develop technology and rapidly exploit breakthroughs, particularly in
  - New methods for change detection, particularly in video collects,
  - New techniques for exploitation of multi-hyper/ultra-spectral sensors
  - New techniques for correlation of other INTs, especially SIGINT

- Use a commercial-like business model for TPED acquisition
  - Use NRO's acquisition infrastructure as appropriate for streamlined acquisition, but under the aegis of NIMA

NIMA cannot afford to fail at either primary mission: operations or modernization. Both activities need to be on par with one another.

RECOMMENDATION 4: Nurture U.S. Commercial Imagery and Geospatial Industry

It is distinctly to the advantage of the United States for U.S. commercial industry to dominate the emerging global, geospatial information industry. This dominance will discourage civilian international launches. It will decrease technology transfer to other nations in the area of satellite sensors and software exploitation techniques.

Therefore, the government should nurture—but not subsidize—that growing domestic industry. The Director of NIMA should execute a balanced, strategic plan to fully exploit commercial capabilities for both routine production and for modernization as they emerge.

- Set an aggressive outsourcing goal for production
  - NIMA has certified that industry can build selected products
  - Contract with industry to scale up their capabilities
  - Prepare to transition from in-house production to outsourced production for a substantial number of products
  - Refocus government production assets to high end products
- Restrict government collection by tasking national systems to collect only on that which cannot be procured competitively from U.S. commercial sources
  - Increase NIIRS threshold for NRO collection as the commercial capability matures
- NRO should advance all dimensions of the technology envelope, not just resolution
  - The DCI should use the authority of Presidential Decision Directive #23 to relax commercial prohibitions and take other actions so that U.S. commercial industry is always able to be slightly in advance of its competition
  - Create contracts for commercial collection, production and exploitation services
- Use contracts to enforce standards and quality
- Facilitate direct access by users
- Facilitate user-funded acquisition options

RECOMMENDATION 5: Resource Allocation: The SecDef and DCI Must Sufficiently Fund All Elements Critical to Imagery and Geospatial Information Superiority

To develop a system that delivers information advantage, all aspects of the information system must be funded: information accession, processing, exploitation, and dissemination. Today, national and tactical collections are reasonably funded. Commercial collection and services and the construction of the TPED system are not sufficiently funded.

TPED is reported to be budgeted at least about $1.5 billion over the FYDP. It will require $3 billion. That bill should be addressed in the current budget process. Commercial collection and services are likewise under funded with about $25 million in NIMA's FY00 budget and a total of $400 million over the FYDP. A multi-year commitment to buy commercial services needs to be made, as part of nurturing U.S. commercial industry.

RECOMMENDATION 6: Protect and Extend U.S. Geospatial Information Superiority

On the defensive side, the United States must protect the capability delivered by its imagery and geospatial information systems, and must prepare to operate with a degraded capability. On the offensive side, the United States should develop a clear understanding of what imagery and geospatial products potential adversaries may access, and what vulnerabilities that creates for coalition and U.S. forces. DoD must also recognize that access to this imagery will enable potential adversaries to better understand U.S. sources and methods. The United States must prepare for attempts to deny users these methods.

In addition, the United States needs to further hone its ability to penetrate adversaries' systems, to deny their access altogether, and to deceive them where possible.

The Task Force recommends that the following actions be taken:

- The ASD(C3I) should determine how to protect TPED
  - Address effect of loss of product to all users (both high and low echelons)
  - Determine how to detect and mitigate adversarial manipulation of product
- The Chairman of the Joint Chiefs of Staff should determine how those threatening the United States might obtain and use imagery
  - Determine what they can know from commercial and international sources
  - Identify denial and deception techniques
- The Chairman of the Joint Chiefs of Staff should assess how to maximize differential information capability via Red-Blue exercises
  - Use commercial companies to assist the Red forces
- The DCI, together with NIMA as subject area expert, should assert responsibility for security classification regulations, threat definition and the direction of policy and guidance related to foreign satellite sales and national imagery policy (Presidential Decision Directive # 23)
- DCI should task the National Intelligence Council to periodically report on the state of international developments in remote sensing

RECOMMENDATION 7: Evolve NIMA to a Smaller, Elite, Mission-Driven Organization

The creation of NIMA was timely and its charter was appropriately defined. NIMA must continue to rapidly adapt itself in order to achieve its mission. In particular, NIMA must develop greater expertise in the design and development of complex distributed information systems. It needs to strengthen its deployment and training components. It needs to downsize to complement production outsourcing and at the same time increase the internal expertise so related to defining future state-of-the-art production.

- NIMA needs to be more organic. It must:
  - Deploy more people to the field and at NRO
  - Integrate more Service personnel at NIMA
  - Augment operational support organizations similar to the National Intelligence Support Teams (NISTs) and National Security Agency's Cryptologic Support Group (CSG)
- The Director of NIMA should report to the Deputy Secretary of Defense on any administrative actions that are needed to achieve this goal. They should include but not be restricted to:
  - Human resource issues involved in workforce skill mix changes and downsizing
  - Transitioning resources in order to be able to stop old systems and replace them with new systems
  - Contracting efficiencies to enable production outsourcing under commercial constructs
  - Fiscal management; resolve some of the Joint Military Intelligence Program (JMIP) and National Foreign Intelligence Program (NFIP) disconnects
  - Endorsement of NIMA legal authorities within DoD and the Intelligence Community

In summary, NIMA has a key role to play in achieving the information superiority that is critical to both national and military users. Without an effective TPED, information superiority cannot be attained, regardless of U.S. collection capability. To achieve the needed information superiority, NIMA must become a world-class information delivery organization. It must, in fact, be the functional manager of the imagery and geospatial community. It must give more priority to modernization and not permit the pressures of routine operation to dilute and delay modernization. NIMA must become a smaller, elite mission-driven organization.

APPENDIX A.

The National Imagery and Mapping Agency and the Broader Imagery and Geospatial Community

Created in 1996, NIMA provides a variety of worldwide imagery and geospatial products for U.S. and allied forces. Figure A-1 shows the organizations that were combined to create NIMA. NIMA's mission is ensure that U.S. forces and national decision-makers can operate in an environment of superior imagery, imagery intelligence, and geospatial information:

The Department of Defense (DoD) Directive 5105.60, dated 1 October 1996, designates the Director, NIMA as the functional manager for imagery, imagery intelligence, and geospatial investment activities within the NFIP, the JMIP, and the Tactical Intelligence and Related Activities (TIARA) program aggregate. It is NIMA's goal to assist the IGC in advanced planning, in promoting common standards and interoperability among USIGS systems, and in making cost-effective resource allocations.

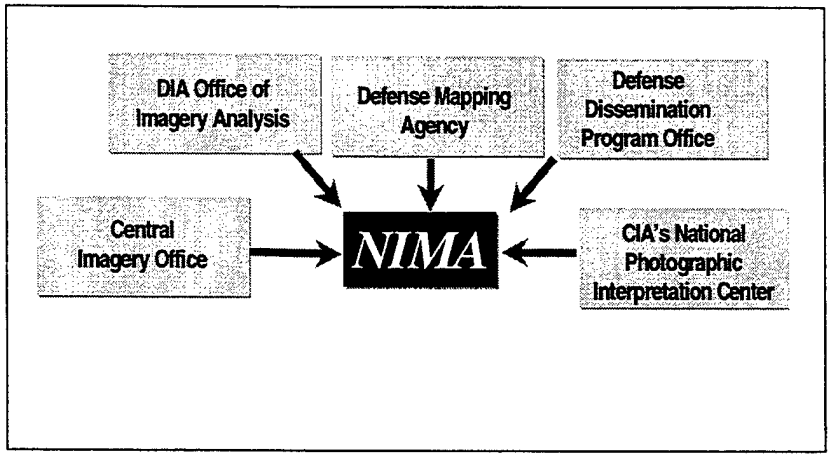

Figure A-1.NIMA's Challenge: Enable Information Superiority in a Changed World

In response to a very diverse customer base, NIMA coordinates, integrates and manages the intelligence community and military geospatial information program. NIMA produces hundreds of thousands of products annually to satisfy many DoD and other federal agency requirements. Among NIMA's products are near-real-time and archived images and military maps, charts and geodetic products and services, comprising some 230+ product lines and services. NIMA also has statutory responsibility for providing products and services for worldwide safety to navigation (both land and sea).

The imagery and geospatial community that NIMA leads includes cooperating commands, services, agencies, and departments within the United States Government, foreign governments and private sector organizations involved in the acquisition, production, exploitation, and dissemination of imagery, imagery intelligence and geospatial information.

NIMA fosters extensive partnerships with others, including commercial and academic institutions, to share information. Currently, NIMA is increasingly relying on industry to provide routine products.

NIMA and the entire imagery and geospatial community are responsible for the acquisition, production, exploitation, and dissemination of imagery, imagery intelligence and geospatial information to satisfy the information needs of its customers. These customers encompass decision makers at all levels of government who are responsible for United States national security, as well as theater, joint, and tactical commanders. As the geopolitical world has shifted from bi-polar Cold War to multi-polar post-Cold War, demands on NIMA have grown, much like demands on the rest of the intelligence community.

The following are aspects of the increasingly difficult national customer needs:

- Information supporting Presidential Decision Directive (PDD)-35.
- Actionable worldwide intelligence information delivered in time to influence policy decisions. The growth in new world threats has made this dimension more difficult. For instance, unforseen events like the May 1998 nuclear tests in India and Pakistan highlight the stress placed on the intelligence community to collect and analyze the right information
- Timely, actionable information regarding threats and flash points
- Integration of collection, analysis, and generation of information from multiple sources for use in developing comprehensive and effective national security strategies
- Access to new types of imagery, geospatial, and MASINT information from new spectral sensor types
- Access to both classified and unclassified imagery and geospatial information
- Ability to fuse, visualize, and share situational information with allies

Coupled with increasing demands from national-level decision-makers, the demands on NIMA by the military customer are also increasing. The advent of precision weapons and worldwide deployment translate to requirements for NIMA to increase both geographical coverage and geospatial accuracy. In the 1970s and 1980s, the typical maneuver map sheets only had to be good enough to locate major features, such as a building. With precision weapons, NIMA must provide sufficiently accurate information to acquire the intended target. This requires accuracy better than 100 meters. Some examples of NIMA's products to meet warfighter needs include:

- United States Strategic Command (USSTRATCOM) requires precise coordinates for targeting and navigation, Terrain Contour Matching (TERCOM) map sets for cruise missile navigation, digital terrain elevation data (DTED) for mission planning and aircraft navigation, aeronautical charts with intelligence data overprints for Single Integrated Operations Plan (SIOP) bomber/tanker missions, gravity data for missile launch and trajectory and relocatable target analysis data.

- The bulk of current requirements to support land combat forces consist of hardcopy topographic line maps and tactical terrain analysis databases. The Army is transitioning to the use of digital products and is increasingly using raster-based map background products for command-and-control and mission planning systems. Elevation data is used for mission planning and basic battlefield visualization. The emerging modeling and simulation community requires much more detailed and robust digital data than is currently available in most areas of the world. Army systems currently being fielded have been designed to use tactical terrain data (or its predecessor interim terrain data) which is not generally available. An additional requirement exists for controlled imagery to serve as a stable geometric framework for overlaying geospatial data produced by field units.
- Naval forces asserted a requirement for worldwide coverage in a digital nautical chart format to support navigation systems and command-and-control systems, operable by the end of 1997. The Navy also requires broad-area coverage of terrain and controlled imagery to support mission planning and digital point-positioning databases for accurate targeting. To date, the requirement is unmet.
- Air forces require broad-area coverage for mission planning; terrain and vertical obstruction information for aircraft safety, flight data for use in the cockpit, gravity data for low-altitude flight and the ability to generate very precise point positioning data for large numbers of accurate tactical target positions.
- The Marine Corps has traditionally required a wide array of imagery and geospatial support due to the integrated Marine Air Ground Task Force (MAGTF) concept of organization, doctrine and missions. Land, air, and sea missions focused on the littorals require a new and better way of packaging nautical, surf/beach, and hinterland geospatial data into a deconflicted, integrated and seamless database to support "operational maneuver from the sea."
- The users require unclassified imagery products.
- Special operations forces require very detailed information in small operating areas.

NIMA has many sources of input data. NRO is responsible for building and operating U.S. government satellite-based sensors. The Services have oversight for program, assets and budget related to airborne intelligence collection, including the U-2; Tier II, Tier II+, and Tier III- UAVs; TACUAV and F/A-18 collectors; and all deployable imagery ground stations (including satellite receive ground stations for national imagery).

To augment NIMA survey data collection, terrain, geodetic and beach surveys are carried out by the Marine Corps and Army topographic units. Hydrographic data (depths of water, nature of bottom, and tides and currents in a given area) are collected by the Navy, National Ocean Service (NOS), and foreign governments for NIMA. Extensive geodetic and gravity source data are acquired by NIMA under commercial and academic agreements.

The Army's Topographic Engineering Center (TEC) is part of the Army Corps of Engineers. TEC is the lead laboratory for all technology-based in-house R&D in topography. TEC and NIMA work together on a number of development projects. TEC exploits NIMA

data where it is available and gathers it where none exists. TEC also plays a critical role in gathering and filtering Army requirements for geospatial information and in advocating the Army's new systems' capabilities and needs for geospatial information and services.

The Navy, augmented by ships belonging to NOAA, maintains a fleet of eight multipurpose ships to collect hydrographic and bathymetric data worldwide. Along with an international hydrographic cooperation program, the Navy can minimally meet CINC requirements in high-priority areas. Advanced technology such as airborne laser bathymetry and autonomous vehicles is essential to improve future collection capabilities.

The NOS is part of NOAA in the Department of Commerce. The NOS provides aeronautical and nautical charts and related information for safe navigation of marine and air commerce in the United States and its territories. NIMA produces similar charts and information in foreign areas for DoD users and marine navigators. The NOS also provides limited backup printing capability for crisis situations, essentially a one-press capability. The NOS distributes NIMA aeronautical and hydrographic charts and publications to the public. Additionally, the National Geophysical Data Center under NOAA supports digital geophysical data collection and dissemination.

The Defense Modeling and Simulation Office (DMSO) reports to the Director, Defense Research &Engineering (DDR&E). DMSO is responsible for establishing interoperability and standards for DoD Modeling and Simulation (M&S) efforts. The M&S community is a user of geospatial information. Digital terrain and atmospheric models are the foundation of many simulation tools. Other geospatial information include mission space visualization and computer-generated force movement analysis tools. While the Army, Navy, and Air Force serve as Executive agents for ground, sea, and air/space respectively, NIMA has an office that develops the standards for data formats so that different simulations can share the same data efficiently and effectively.

The USGS is primarily active in domestic mapping for digital elevation maps (DEMs), standard-scale-based quad sheets and digital orthophoto quadrangle products. NIMA has contracted with USGS for the production of DTED. USGS has responsibility for domestic land surfaces while NIMA is responsible for mapping foreign land areas. NIMA purchases USGS maps at retail cost and provides them to DoD users. USGS also provides a limited printing capability in support of the DoD in crisis situations or for disaster relief. USGS provides public distribution of unclassified NIMA productions and imagery.

NIMA has international exchange agreements with over a hundred foreign nations, many of which involve the exchange of mapping, charting, hydrographic, gravity and geophysical sources. Through its own active program, NIMA also acquires several thousand maps and charts per month, catalogs them and holds an extensive collection of maps and charts. Smaller collections of maps and charts exist at other DoD and federal agencies.

Digital imagery and geospatial products developed uniquely by the CINCs, Services and DoD agencies include those described below:

- Special software is needed to display and manipulate digital maps on a variety of computer architectures. The Air Force's Common Mapping Program, Navy's Chart II and the National Security Agency's OILSTOCK are among the available software tools and products.
- Elevation data in digital format is used for weapon system navigation (B-2 terrain avoidance, cruise missile INS updates, etc.) and in mission planning systems (USSTRATCOM's Route Planning and Evaluation System). These data are often merged with digital maps or imagery to provide visualization for mission rehearsal and simulations.
- Geographic information systems, such as Defense Intelligence Agency's Generic Area Limitation Environment (GALE) offer intelligence capabilities through their ability to assemble, store and manipulate geographically referenced data.
- The Joint Mapping Tool Kit, as agreed upon by the Services and NIMA, is now part of the Global Command and Control System (GCCS) baseline and will be upgraded as future versions of GCCS are deployed.

APPENDIX B.

Terms of Reference

THE UNDER SECRETARY OF DEFENSE
3010 DEFENSE PENTAGON
WASHINGTON, D.C. 20301-3010

ACQUISITION AND
TECHNOLOGY

08 MAY 1998

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Terms of Reference for the Defense Science Board Task Force on National Imagery and Mapping Agency

You are requested to establish a Defense Science Board Task Force to review the objectives and plans of the National Imagery and Mapping Agency (NIMA) to meet the needs of the national and military intelligence customers as they enter the 21st Century. The Task Force should review NIMA'a roles and missions to serve both national and military customers and its working relations with the members of the intelligence community, particularly the National Reconnaissance Organization (NRO). The Task Force should specifically consider:

- tasking, processing and dissemination strategy, procedures and systems,

- the vision, strategy, and plans (with respect to technology, resources, and organizations) to create an end-to-end process for acquiring raw data, processing and fusing it, then delivering products in order to meet customer needs in a timely and cost/effective way,

- the interoperability of intelligence and operational information delivery system, and

- the strategy to incorporate commercial sources and products with government products to meet government needs.

The Task Force should identify opportunities and any specific problems. Final findings should recommend strategy and specific actions to strengthen the existing capability.

The study will be sponsored by the Undersecretary of Defense for Acquisition and Technology. Mr. Peter Marino and Dr. Anita Jones will serve as Task Force Co-Chairmen. Col Al Shaffer, DDR&E, will serve as the Executive Secretary and Major Wynne Waldron, USAF, will serve as the Defense Science Board Secretariat representative. The study will complete its work within the calendar year.

The Task Force will be operated in accordance with the provisions of P.L. 92-463, the "Federal Advisory Committee Act," and DoD Directive 5104.5, "DoD Federal Advisory Committee Management Program." It is not anticipated that this Task Force will need to go into any "particular matters" within the meaning of Section 208 of Title 18, United States Code, nor will it cause any member to be placed in the position of acting as a procurement official.

J. S. Gansler

APPENDIX C.

Task Force Members

Co-Chairs:

Dr. Anita Jones*	University of Virginia
Mr. Peter Marino*	Firearms Training Systems, Inc.

Members:

Gen Mike Carns, USAF (Ret)	Consultant
Mr. Brian Cullen	Consultant
Mr. James Evatt*	Boeing Information, Space & Defense Systems
Mr. Jeffrey Harris	Space Imaging
Mr. Donald Imgram	Technology Strategies and Alliances
Mr. Lawrie Jordan	ERDAS
Mr. Kenneth Kodama	GTE Corporation
Dr. Joseph Markowitz	Consultant
Dr. Edward McMahon	MRJ Technology Solutions
MG William Nash, USA (Ret)	National Democratic Institute for International Affairs
Dr. Terry Straeter	GDE Systems Inc.
ADM William Studeman, USN (Ret)	TRW Systems & Information Technology Group
VADM Jerry Tuttle, USN (Ret)	Mantech Systems Engineering Corporation

Executive Secretary:

Col Alan Shaffer, USAF	ODDR&E

DSB Representative:

Maj Tony Yang, USAF	Defense Science Board

* Indicates DSB Board Members

Government Advisors:

Mr. Bill Allder	NIMA
LTC Jeff Arndt, USA	DSCINT-POB
Ms. Ann Carbonell	NIMA
CDR Tim Duvall, USN	N20
Mr. Leo Hazlewood	NIMA
LTG James King, USA	NIMA
LTC Doug Lewis, USA	DSCINT-POB
LtCol Michael Rogers, USAF	AF/XOIRY
Mr. Kevin West	AF/XOIRY

Contractor Support:

Ms. Julie Evans	Strategic Analysis, Inc.
Mr. Brad Smith	Strategic Analysis, Inc.

APPENDIX D.

Briefings Received by Task Force

May 28-29, 1998:

Mr. Leo Hazlewood	Formation NIMA
Ms. Roberta Lenczowski	NIMA Operations Directorate Overview
BG Arthur Sikes	NIMA Customer Support Office
Mr. Thomas Early	NIMA Systems Overview
Mr. Darryl Garrett	NIMA Technology Overview
Mr. Robert Zitz	NIMA Future Planning Overview
Mr. Fred Faithful	FIA-Requirements Brief
Mr. Robert Cardillo	NIMA TPED Brief

June 23-24, 1998:

Mr. Dave Kier	NRO Corporate Overview IMINT Overview
Col Olsen	IMINT baseline operations
Mr. Krum	Enhanced Imagery System (EIS) Capabilities/schedule NIMA relationship/community changes Gap Analysis
Mr. Fred Faithful	FIA Requirements
Col Kimberling	FIA Program Overview
Dr. Bill Mularie (former Director, Systems and Technology, NIMA)	Remarks
MG Robert Rosenberg, USAF (Ret) (former Commander, DMA; Co-Chair, 95 DSB Mapping study, and member of the Gates	Remarks

Commission)	
Mr. Gary Fuller (Space Imaging, formerly Booz-Allen a key member creating NIMA strategic vision)	Remarks
Ms. Beth Larsen (Minority Staff, House Permanent Select Committee on Intelligence)	Remarks
Mr. R. Evans Hineman (President, TASC)	Remarks
Mr. Duane Andrews (SAIC; Former ASD(C3I))	Remarks
July 30-31, 1998:	
General Tiiu Kera	STRATCOM
Col William Russell	Southern Command (SOCOM)
Gen Ray O'Mara (Ret)	Views on DMA and NIMA
Mr. Tim Sample Mr. Michael Meermans Ms. Mary Engebreth	HPSCI
Col Richard Zahner	C4ISR
Mr. Michael Decker	Marine Corps
Capt Robert Weidman	Navy Sixth Fleet
BG Carol Elliot	J2
Mr. Stephen Wood Mr. Al Koeninger	Crime & Narcotic Center/CIA
Mr. Bruce Price	FEMA
Mr. William Wood	Department of State
Mr. Notra Trulock	DOE
Mr. Kevin West	Air Force
CDR Trish Beckman	Joint Air To Surface Standoff Missile (JASSM) Program Office

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Dr. William Roper	TEC Overview
Mr. Rege Orsinger	Operational Support Overview
Mr. Laz Greczy	Imagery and Geospatial R&D Program
Donald Wells, Brian Hatchl, William Schroeder	Pax River demo by AOT/MRJ

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Mr. Bill Allder	NIMA Programs Using COTS
Dr. Kathy MacDonald	NIMA System Engineering —SAIC
Mr. Dennis Lambell	NIMA Libraries —GDE
Mr. Mike Thomas	Integrated Exploitation Capability —LM
Mr. Jim Proctor	IAS/Common Client —Harris
Mr. Clay Ancell	NIMA Production Outsourcing
Mr. Jim Proctor	Harris
Mr. Red Gilliam	Intergraph
Mr. Cliff Greve	SAIC
Mr. Jeff Harris	Commercial Remote Sensing
Mr. Joe Dodd	Orbital
Mr. Herb Satterlee	Earthwatch
Mr. Raj Dutt/Mr. Bill Robinson	RDL
Mr. Brian Bullock	Intermap
Mr. Jeff Harris	Commercial Remote Sensing
Mr. Harry Utter	Logicon-Multispectral
Mr. Jeff Harris	Commercial Overlay

Mr. Kass Green	Pacific Meridian
Mr. Lawrie E. Jordan	ERDAS
Mr. Chris Haakon	Autometric

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Ms. Karen Irby	USGS
Col Robert Reynolds	DISA Communications
Mr. Morris (CMO)	Hyperspectral Technologies
Ms. Laura Robinson	NIMA Commercial Strategy
Dr. Joseph Markowitz	Security Issues
Mr. Stephen Long	NIMA

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Dr. Paylor, NASA	Overview of Earth Science Enterprise
Col Herb Kemp	NIMA Support to Aerospace Operations
Col Mehaffey; Col Pierce	Army
LTG Hughes, USA Charlie Allen	Discussion Assistant Director of Central Intelligence for Collection

January 14, 1999:

Dr. David Whelan	Discoverer II
LCDR Jon Todd Ross	Recce 2010 II

APPENDIX E.

Findings and Other Recommendations

The Task Force dealt with many issues. To be most effective, we focussed this report on the highest priority recommendations that were most relevant to NIMA. In this Appendix, we summarize additional Findings and Recommendations, some of which amplify the findings and recommendations discussed earlier in this report.

1. Establish and Enforce Uniform Protocols for Reconnaissance Data

Findings

- Airborne imagery and geospatial data are not fully integrated into the TPED architecture
- Reconnaissance data are not always adequate for incorporation into national archival databases
- Unmanned air vehicle sensors (existing and planned) do not uniformly record geospatial registration
- There is no effective focal point for airborne reconnaissance standards since the Defense Airborne Reconnaissance Office was disestablished
- There is a need for standards and interoperability in data collection across platforms

Recommendations

- NIMA, as functional manager, has the charter for the end-to-end geospatial architecture (including data registration of other INTs). NIMA should set the standards for reconnaissance data recording to assure that field data can be used for quality archival products and can be manipulated by the appropriate TPED exploitation tools
- Adherence to data and interoperability standards is the responsibility of individual Program Managers—NIMA should verify compliance during Defense Acquisition Board (DAB) reviews

2. Forging an Integrated Operational Picture—Integration of the INTs

Findings

- Significant "value-added" derives from integration of INTs
- The geospatial framework is the single framework in which products from all the INTs can be fused

- INTs have not converged—for example, IMINT, HUMINT, SIGINT, and MASINT products are rarely fused together
- Where products from the other INTs have a natural geospatial registration, their formats need to be compatible
- SIGINT and HUMINT remain the primary INTs that are not commercially available; there is special opportunity to exploit their fusion into the geospatial framework

Recommendations

- NIMA should lead in defining standardized/interoperable INT product formats that will permit the integration of products from multiple INTs to form an integrated operational picture
- NIMA should work with the agencies responsible for the other INTs to ensure that their (geospatially registrable) products can move through and be processed in TPED with no unnecessary, bureaucratic, or other undue delay
- Planning for the convergence of the NIMA, CIA/DIA, NRO, CMO and NSA exploitation infrastructures should begin now with ongoing TPED architecture development and planning efforts

3. Exploiting Motion Imagery

Findings

- Streaming video presents an entirely new analytic challenge. Exploiting streaming video requires a form of dynamic change analysis that is far more demanding than that of static images in some instances
- NIMA processing is geared to static images
- Increasingly video collection, particularly from UAVs, is becoming more pervasive
- Future operations will likely include video sensors operating at frame rates geared to human visual processing
- Video technology needs to be developed and exercised, particularly the TPED segment

Recommendations

- NIMA, and the DoD, need to exploit motion imagery:
  - Develop/access softcopy analysis means/methods in order to rapidly exploit video
  - Develop the techniques to store and retrieve video efficiently and effectively

- Create the CONOPS associated with motion imagery

- Include video and motion imagery in modeling and simulation efforts and in warfighting experiments

4. Ensure Rapid Transition of Breakthrough Capabilities

Findings

- NIMA does not have a strong in-house or contract program to conduct R&D for better exploitation

- Multi- and hyper-spectral imagery is the single most promising (current) technology

  - The challenge is not to build the sensors, but to exploit the data, and to do so efficiently

  - Libraries and signatures (against alternative backgrounds) need to be developed

  - The ability to perform fixed and moving target detection and identification (with low numbers of false alarms) need to be proven

- Moving Target Indicator analysis (for example, for JSTARS, DISCOVERER II, UAVs, etc.) needs to be refined

Recommendations

- NIMA, in concert with DARPA, NRO and the Services, should ensure that the DoD has a strong S&T program

  - It should not duplicate, but build on, industry research and development

  - NIMA should partner with DARPA (as does DISA) to facilitate quick exploitation of breakthroughs

- Pursue development of:

  - New methods for change detection,

  - New techniques for exploitation of multispectral / hyperspectral data, and

  - New ways to correlate IMINT with other INTs (especially SIGINT)

5. S&T for Intelligence Exploitation

Findings

- The ability to exploit emerging sensors for the analysis of foreign technology capabilities should be strengthened

- A variety of emerging "hard" targets challenge the Intelligence Community; they require new exploitation techniques

Recommendations

- Enhance the Community's capability to integrate all-source information for purposes of foreign technology analysis

6. Structure Information for Release to Coalition Partners; Maintain a Policy Option to Withhold Selected Information

Findings

- DoD needs to develop trust among coalition partners
- Excluding them from data, some of which is globally available from other sources, both irritates the relation, and reduces their potential effectiveness as partners
- Today, coalition partners do not operate with us using a common operational picture
- If coalition operations are to be the norm, DoD needs to structure its technical policies, practices, processes and procedures so that the US can execute its political policy without having to change ongoing daily processes and procedures

Recommendations

- Structure the geospatial information database in an unclassified fashion; there should always be a shareable common operating picture
- The baseline TPED system and tools should operate at an unclassified level
  - TPED should be based on an open-systems architecture
  - Actual data is classified if "exotic"
  - Specialized algorithms may be classified
- To the extent possible, use specialized algorithms which extract information that might need to be restricted from an unclassified data product (as was demonstrated at the 7th Air Force KCOIC at Osan, ROK)

7. Dissemination Challenges

Findings

- Information superiority will require on-demand delivery of information to lower levels; commercial progress will drive cost down and vulnerabilities up
- DISA does not plan to provide adequate communications; commercial capability will meet requirements
- A market-based rationing model is needed
- There must be a minimum essential capability for assured communications
- Other service should be shed to commercial providers

- The "last tactical mile" is still the most difficult service to provide

Recommendations

- NIMA must assume that it will be using communication services provided by both DISA and commercial sources
- The TPED architecture must provide for dissemination over the "last tactical mile," without knowing now where and when the CINCs/Services will require it

8. Integrating Intergovernmental Databases (NASA, USGS, etc.)

Findings

- NASA and the USGS have strong remote sensing and geospatial processing programs and capabilities that can provide support for national and military users
- NASA and its contractors are pushing the state-of-the-art in hyperspectral and multispectral imaging, SAR and associated TPED-like functions
- NIMA has established liaison programs with both organizations, but more can and should be done to exploit their programs and capabilities

Recommendations

- NIMA should consider active participation in NASA remote sensing programs and associated TPED-like efforts to motivate rationalization, interoperability, and collaboration
- NIMA should establish interagency arrangements with USGS for procurement of geospatial and imagery services on an as-needed basis to support the warfighters and national users

9. Structure Relationship with NRO as the "Captive" Agent for Imagery and Geospatial Information

Findings

- NRO works for more customers than NIMA—at the same time, one of its major functional activities is to service NIMA requirements
- NRO investments *should* be more closely coordinated with those of NIMA
- NIMA is under-represented within the NRO, and vice-versa
- The NRO Future Imagery Architecture needs to be adapted to converge with TPED and NIMA CONOPs

Recommendations

- NIMA's end-to-end architecture must encompass FIA

- NRO investments should require NIMA concurrence
- Deploy more NIMA personnel within NRO and vice-versa

10. Make the Imagery and Geospatial Databases for Training/Experiments/ Rehearsal Interoperable

Findings

- DoD is undertaking significant efforts in modeling and simulation and in warfighting experimentation to craft tactics, techniques, and procedures for 21st century military operations
- Training, exercises, and rehearsal for the combat employment of precision capabilities and precision weapons require geospatially-registered information
- Today, more often than not, contractor-unique (proprietary) geospatial databases are the norm; capabilities need to be interoperable, and are not

Recommendations

- NIMA should develop the national modeling and simulation standard for imagery and geospatial information interoperability and require its use in military and national user applications by a date certain

11. Authenticate and Ensure Quality of Imagery and Geospatial Products

Findings

- There is a greater need for authentication and assurance of the quality of data, products, and industrial capabilities
- There need to be approved techniques for assessing product quality, both during the product creation process and after a product is extant
- There need to be standards for (meta-data) annotation of products so that quality as well as integrity pedigrees clearly label the products. Watermarks are one technique for integrity annotation
- Standards for geospatial products should be enforced
- All sources need not be certified—users need to be aware of the integrity annotations of the information products on which they rely

Recommendations

- NIMA should define standards for assuring integrity of process
- Products should carry (meta-data) annotations that describe their quality and their integrity
- NIMA should certify providers' integrity and quality processes

- NIMA should train users to make sound judgements about security, integrity and quality related to TPED and the products that it will disseminate

12. Personnel

Findings

- There is a shortage of imagery and image intelligence analysts today; it will increase
- Their training must keep pace with the new technologies, both new exploitation techniques and new sensor technologies

Recommendations

- NIMA should manage DoD cadre of Geospatial Information Specialists
- Their training should be continual and should be focused on developing skills in the new technologies

APPENDIX F

THE GEOGRAPHIC CINC: RECEIVER AND GENERATOR OF INTELLIGENCE

USING, FUSING AND EXCHANGING INFORMATION

The main body of this report has identified the challenges facing NIMA and crafted recommendations well suited to the future needs of the customer, both at the national level and that of the field user, usually a headquarters entity. In the case of delivery to the latter, however, the product has often not reached the ultimate user, the tactical forces, in a timely manner. The tactical forces may be several commands or management echelons removed, perhaps even a continent away, from the NIMA "theater delivery point."

This appendix discusses several issues relating to system effectiveness at the theater level and below. Though, beyond the scope of this study's Terms of Reference those issues bear on the ultimate effectiveness of a potential new NIMA/TPED system. The objective of this discussion is to familiarize the reader with additional work that needs to be undertaken for the development of a successful end-to-end TPED system. The ideas in this appendix address the user's changing role; they complement the main report, but do not necessarily reflect the majority of the Task Force.

THE ALTERED ROLE OF THE GEOGRAPHIC CINC AND EMERGING LIMITATIONS

The Post-World War II Soviet threat to the United States was considered so serious that, for the first time in history, the United States adopted a standing force posture in peacetime, with a centrally controlled nuclear response force as its main deterrent. This approach required a centric, very robust national intelligence apparatus to provide assessments to the national command authority for decision making. The primary military consumer was the Strategic Air Command, later joined by the U.S. Navy's Ballistic Missile Fleet, both centrally organized, commanded and controlled forces.

With the demise of the central threat posed by the USSR and the emerging importance of regional issues to U.S. national security, military focus has been considerably realigned to emphasize support of the regional CINC. There has been less change, however, in the national intelligence sector. National intelligence agencies still retain a focus on broad national support even, while expanding their support to regional CINCs, particularly in support of engaged operations.

At the same time, the regional CINCs depend largely on their assigned Joint Intelligence Centers (JIC) for intelligence support. The JICs are excellent in their areas of primary expertise – military assessments, building and maintaining order-of-battle databases, equipment capability determinations, etc. However, JICs lack timely access to nationally controlled intelligence and other information, as well as all of the in-place expertise to exploit such information to generate needed assessments and products. To provide a more fulsome picture for the CINC, the JIC depends on information provided by national intelligence agencies, supplemented by national intelligence liaison officers at the JIC.

The resultant picture presented to the CINC thus conforms to that generated by the national level intelligence community. It is, thus, a broad national overview, which can be fleshed out by a more detailed military information generated at the CINC level – a variant on centralized intelligence that fails to sufficiently accommodate regional differences. From one viewpoint, this system is appropriate. However, in a world increasingly seized by regional problems – Bosnia, Kosovo, Iraq and North Korea, etc. – a homogenized national intelligence perspective also has its risks. Because of limited assets, the amount of regional intelligence gathered is a bit thin in any one place. This situation is in contrast to the previous dwell and focus on the USSR and Warsaw Pact during the Cold War. Thus, the CINC, while responsible for his region, looks to Washington for assessments in areas where he lacks intelligence robustness—which is in most areas except that of the regional military assessments.

The CINC is responsible for planning and conducting military operations in his area of responsibility. Today, the strategy calls for the high probability of coalition warfare. Because of the strong U.S. bias in a CINC/JIC assessment, the work may not take into account very important information, perspectives and capabilities of allies and potential coalition partners. One reason for this is that the CINCs get foreign input filtered through Washington. The CINC receives no intelligence directly from theater intelligence sources such as – CIA or Embassy Military Attache Corps (DIA assets). Intelligence from the theater for example; goes first to Washington and then is folded into various intelligence products, with fusion as appropriate. Thus, perspectives of potential and actual coalition/allied partners tend to be viewed through national filtering systems.

Furthermore, at the national level, there is a natural resource allocation and adjudication process that takes place, with intelligence problems ranked on a national scale rather than according to individual CINC concerns or desires. However, the CINCs lack the information sources and collection means to offer a contrasting opinion on collection priorities. The CINCs need to become more competent regional assessors so that their views are strongly considered in DC. Thus, CINC concerns would be channeled upwards into a U.S. system for prioritization, rather than providing the CINC with intelligence assets to task as required. This centrally based response to regional needs occurs particularly during peacetime or tension. In wartime, the CINC has a stronger say in the system.

When a regional problem springs up, national systems swing overwhelming coverage to the issue area, both to close the gap caused by lack of coherent coverage but also to show responsiveness. While this is indeed the necessary response in a centric system many other needs are then immediately dismissed.

Furthermore, when a crisis arises, allies and potential coalition partners will not have had access to the quality and depth of intelligence that prompted the United States to move to military operations. Further, there are immediate challenges regarding multilevel security. And unless there is a compelling need to ensure a common operating picture – such as when the United States is seeking broad political consensus or during coalition combat operations (and even then there is not full disclosure...cf, B-2 operations in Kosovo), the United States shares information sparingly. Not surprisingly, there are worrisome gaps in perception and strong feelings of resentment among coalition partners in such circumstances, much of it warranted from the standpoint that if they are going to risk their forces and national treasure, why should they operate at a lesser level of knowledge and awareness?

THE CINC'S INFORMATION NEEDS:

The United States' experience since the close of the Cold War demonstrates how quickly the government must be able to act in order to achieve its national security goals. Given rapidly developing regional situations and the continued reduction of U.S. force basing and structure overseas, there is growing realization that U.S. success, political as well as military, is increasingly dependent upon *the speed of information exceeding the speed of engagement.* Since there is an increased dependence on coalition operations, the CINC needs information (including intelligence) that can be released to coalition partners that is the common coalition operational and tactical picture, relevant (timely) and reliable (unambiguous).

Several programs are underway to develop a better common operational and tactical picture. The Global Broadcast Service (GBS) is one example of a major initiative underway to provide CINCs and field military commanders with timely and accurate intelligence and information. The objective is access at all echelons and levels of command. This service would have to be secure, accessible world-wide, and tailored to the theater dissemination architecture using a standardized format interoperable with both strategic (national) and tactical (theater joint and service) systems.

The operational requirements document for GBS evinces clear awareness of the issue of providing coalition access and includes clear statements that the system will adhere to releasability rules. However, while the vision policy statement may be correct, the field reality may well be manual rather than automatic. The United States is moving at the "speed of light" while its partners continue to use manual systems for the most part. The resulting incompatibility is an increasingly serious long-term national security and coalition warfighting matter. New thinking is needed to ensure that GBS and other developments at the theater level bring the United States closer to having a common operational picture.

THE NIMA PRODUCT

When the NIMA product is provided to the military field user, usually a headquarters entity, it is normally delivered in a pre-determined, standardized format. Prior to delivery, the product may have been subjected to various forms of "fusion," that is, combined with other intelligence information such as SIGINT, etc., to produce a product with a broader credibility base. However, there is no standardized process that assures partial- or all-source fusion prior to distribution to a field user.

Moreover, to an ever-increasing extent since the inception of uninhabited combat air vehicles, the field user is not only a receiver of NIMA and other source products but also a producer of his own intelligence, employing assigned organic assets. While these systems are properly classified as "tactical" (that is assigned to the field command), their products may also be valuable to users other than the owning tactical force due to its freshness and direct relation to specific circumstances associated with the field mission.

FUSION ISSUES AT THEATER LEVEL

Above theater level, fusion takes place where national entities deem it best in the TPED process. At the same time, the field entity is gathering intelligence using assigned organic assets. The theater J-2 provides overall direction for this collection; lower level commanders have additional input as to how lower echelon tactical assets are to be employed. The theater intelligence asset owners and employers use the collection apparatus consistent with agreed rules and according to their own needs, employing everything from tactical radio intercepts to uninhabited aerial vehicles.

Suitability of Theater-Level Generated Intelligence and Information

Theater-generated intelligence and information is topical and current, although raw and not necessarily accurately recorded by location and mensuration. This and other deficiencies limit the ability to "fuse" the data in-theater with any speed and suitability, if at all. Aside from the not inconsequential problem of orthorectifying geospatial the theater product, the field user needs the capability to be able to merge the field-acquired information with products provided by national and higher headquarters sources. This requirement must be exercised in a discretionary fashion to ensure that it does not become an additional echelon in the distribution of product. But, it must be available as an option to ensure that the best possible product is delivered to the person responsible for directing as well as conducting military operations.

Field Knowledge of Product Origin and Manipulation (Fusion)

In addition to understanding its own means and processes, the field command must be deeply knowledgeable of the central TPED process. While detailed sources and methods should not be revealed, the field command must at least understand the provided material's currency, its reliability and what information was "fused" in developing the final product. Such knowledge will ensure that organically assigned intelligence assets (tactical assets) are tasked adroitly to generate the best possible intelligence picture for field decisions.

Up-channeling Field/Organic Intelligence

Fusion of field-derived intelligence with nationally provided product both improves and alters the field's perception of a situation. In micro ways, such differences in understanding are irrelevant; however, when viewed collectively across a battlefront, the extra step of field fusion may result in a differing perception of ground truth at the national level and at the field level. This problem is significant and while it should be self-correcting over time, it could result in a lagging national perspective, a dangerous scenario in fast developing situations, particularly where a decision to use force is being driven by critical political aims. The Kosovo case would appear germane. So, just as the field wishes to be alerted to key new information flowing into national registers, so must the national INTs identify their "tell me if you get" lists.

INTELLIGENCE/DATA BANK STORAGE

Since the field systems cannot store the volume of information available from external national sources, these systems may well be aligned in a fashion materially different from that of the intelligence and information supplier. For command reasons, the field must structure its databases and/or design access software and storage capacity to facilitate efficient yet secure access, manipulation and extraction by the operational user. This is a difficult problem. The user will wish to query databases in ways substantially different from a nationally based analyst, using an execution/ employment outlook, such as by description of intended purpose (eliminating the electrical grid), by intended special capabilities user (Special Forces). For example, the filed user may wish to query by particular operational option (eliminate fuel availability), or by a particular weapons system (TLAM). Accordingly, not only must storage structures be operationally relevant; they must also be carefully cross-referenced and automatically cross-linked to ensure that new information forwarded from senior organizations is promptly and properly available.

DATA STORAGE "PUSH"

The field user has limited storage and limited transmission means. Accordingly, the current thinking has been to make as much available to the field as possible and allow the user to "pull" as needed, thereby permitting the user to control and efficiently allocate the communications pipe and the field storage means. At the same time, there is a constant flow of information into the central and field intelligence databases, which is potentially relevant to ongoing operations flowing. The challenge is to be able to set up flag mechanisms at the national level which automatically forwards desired and pertinent information without an initiated query, especially during ongoing operations or during work-up of operations about to be initiated. The control mechanism for such flow would have to be very sophisticated. A high order "tell me if you get" type system would be appropriate rather than a keyword type system due to the risk of overload and irrelevant material. This mix of push/pull requires careful balancing and tailoring to insure the user gets what he needs but is not overwhelmed.

"SENSOR-TO-SHOOTER"

With the continued expansion of field collection means and its tactical relevance plus the growing digitization of weapons systems, there is increasing potential for sensor-to-shooter employment – that is, programming or tailoring a sensor to detect a defined information set that can be made directly available to a response system. Such efforts have been underway ever since the IGLOO WHITE/Task Force Alpha program was conducted during the latter years of the Vietnam War. This effort was near real time at best but it is exemplar of what might be done to detect, evaluate, fuse, assess and act on information in a near real time context. The growing challenge is how does one integrate this bottom-up, field-based intelligence gathering effort with the top-down, nationally based intelligence gathering system? Successful implementation of a seamless and transparent information exploitation loop (national-tactical-national) is probably the key to future effectiveness of "sensor to shooter."

THEATER INTELLIGENCE SUPPORT ORGANIZATION

The regional headquarters has an integral (but not necessarily collocated) Joint Intelligence Center that is manned by all services and serves as the regional intelligence support facility for the CINC and his assigned theater service components. The JIC is, at its core, a military intelligence facility, concentrating on regional order of battle. It draws from other sources and databases to round out the intelligence picture that it creates. The JIC has in-place liaison officers from other stovepipe agencies such as NSA, DIA, and NIMA. The CIA representative is normally located with the CINC's staff, not at the JIC. Each theater has a JIC for direct support of the CINC and his assigned component forces. The National Military Joint Intelligence Center (NMJIC) provides national-level military intelligence support and is tied to theater JICs through robust communications. Theater JICs are assigned full responsibility for creation and maintenance of military databases for countries within their theater and have access to military oriented national databases. Access to other national databases is more limited and is provided through agreements with national agencies and/or through national intelligence liaison officers present in the JIC. Liaison officers are very responsive to JIC requests but, as liaison officers, are not responsible for the product generated in response to such requests or the final JIC product. One national level agency has assigned detachments to each JIC for such support, and the detachments do generate intelligence products in cooperation with JIC personnel. However, like the liaison officers, the detachments work for the central agency and not directly for the JIC. The JICs are robust in assigned military personnel for peacetime operations. However, manpower augmentation is required during crisis. For example, more than 100 people augmented the European Command (EUCOM) JIC during the first years of the Bosnia crisis.

MEASURES TO STRENGTHEN JIC CAPABILITY AND CREDIBILITY

Three major alterations to CINC JICs are recommended:

- Increase the contribution of national intelligence agencies to JIC staffing on a permanent basis. The number of people to add will vary by JIC mission and

manning. For example, the EUCOM and CENTCOM JICs are extensively overworked at present due to existing crisis operations.

- Assign national intelligence liaison officers directly to existing staff and analysis positions, thus making them integral to the JIC's functionality and product generation.
- Improve reachback capabilities to maximize use of CONUS/stateside analysts and analysis

These three measures would have the net impact of a de facto Goldwater-Nichols approach to the intelligence function, which is now moving more toward stovepiping) than toward integration. An example is the new personnel system, separate from Civil Service. These assigned national intelligence personnel would serve in responsible line and supervision positions within the existing JIC structure, thereby gaining first hand exposure to the field use of the intelligence function, acquiring a better understanding of the particular contribution of his respective national INT, undergoing necessary career broadening and developing a vastly expanded network to improve the individual's future effectiveness. Their immediate supervisors would rate the performance of these personnel, military or civilian. This step alone emphasizes the fact that they would not be liaison personnel; they would be core to the success of the JIC mission and responsible for the quality of its products. Finally, improved reach-back would capitalize on the extensive CONUS and stateside resources and larger manpower pools.

Resultant Altered Sense of CINC Accountability

This rough sketch of possible changes to the JIC structure materially alters the CINC's role and perspective. Most importantly, with more robust JIC support and a broader assigned skill base, the CINC would be accountable for broad assessments of his region, comparable to those generated at the national level. This responsibility would shift CINC focus more toward the military situation in the region and less toward the political. As an enfranchised regional assessor, the CINC would be expected to comment on national assessments, citing his own analytic evidence for differences in perspective. This creative tension would identify differences, thus focusing effort in areas where additional clarity and understanding were needed.

The Last Tactical Mile

Despite the absolute necessity of having timely and usable linkages to the "shooter," there is insufficient awareness of the growing ambiguity of who is responsible for this link. Prior to Goldwater-Nichols, this was an undisputed parent service responsibility – organize, train, equip. Over the past decade, the assignment of this responsibility has become far less clear due to the creation of new joint-defense entities; growth of joint authorities; and redistribution and realignment of responsibilities among a growing number of players: CINCs, Joint Force Commanders, defense agencies, and the intelligence community. When allied/coalition operations are added, the ambiguity grows as to who has authority, responsibility and accountability. This is a first order problem. Serious attention needs to be focused on this growing ambiguity to ensure that

the responsibility for this critical link – "the last tactical mile" – is clearly understood, properly resourced, and operationally sufficient. Such clarification is necessary so that information and intelligence is delivered in a timely and reliable (unambiguous) manner.

SUMMARY

The management and resource recommendations identified in the main body of this NIMA report, if adopted, will leverage America's strength in intelligence gathering. The resultant new capabilities will provide the means to evaluate intelligence for decision and action faster than an adversary will be able to understand what we have learned or react to the directed consequences. These capability improvements at the national level must be matched by similar improvements at the regional level. The responsible CINC needs his own means to evaluate the region as a complement to national efforts. By being provided the necessary tools, the CINC takes on full accountability for the intelligence assessment of his region and becomes a much more responsible player in the debate.

At the same time, the field user is becoming increasingly capable of generating useful intelligence through assigned organic assets that is of interest to the national as well as the tactical user. Means and methods need to be devised to up-channel and cross-channel such information beyond CINC regional bounds for inclusion in national intelligence assessments as well as use by other geographic CINCs.

Implicit to all of the foregoing comments is the problem of increased information exchange at all echelons in an environment of constrained communications throughput. Major attention should be focused on this serious limiting factor and priority should be given to devising balanced solutions.

Bottom Line: ***The speed of information*** **– releasable, relevant and reliable–** ***has to exceed the speed of engagement.*** Users at all levels, from national all the way through the chain of command to the last tactical mile user, need the right intelligence information support at the right time in the right form – sensor-to-shooter – for the United States to prevail in its superpower role.

APPENDIX G.

Glossary

ABC	Activity-Based Costing
ACTD	Advanced Concept Technology Demonstrations
ADS	Advanced Distributed Simulation
ASD	Assistant Secretary of Defense
ATD	Advanced Technology Demonstration
C3I	Command, Control, Communications and Intelligence
CI & GP	Consolidated Imagery and Geospatial Program
CIA	Central Intelligence Agency
CIB	Controlled Image Base
CINC	Commander-in-Chief
CMS	Community Management Staff
CONOP	Concept of Operations
CONUS	Continental United States
COTS	Commercial Off-The-Shelf
CSG	Cryptologic Support Group
DAB	Defense Acquisition Board
DARPA	Defense Advanced Research Agency
DARO	Defense Airborne Reconnaissance Office
DCI	Director of Central Intelligence
DEM	Digital Elevation Maps
DEPSECDEF	Deputy Secretary of Defense
DIA	Defense Intelligence Agency
DII	Defense Information Infrastructure
DISA	Defense Information Systems Agency
DMA	Defense Mapping Agency
DMSO	Defense Modeling and Simulation Office
DoD	Department of Defense
DSB	Defense Science Board
DTED	Digital Terrain Elevation Data
ELINT	Electronic Intelligence
EUCOM	European Command
FIA	Future Imagery Architecture
FYDP	Future Years Defense Program
GALE	Generic Area Limitation Environment
GBS	Global Broadcast Service
GCCS	Global Command and Control System
GIS	Geospatial Information System

GPS	Global Positioning System
GUI	Graphical User Interface
HUMINT	Human Intelligence
IC	Intelligence Community
IGC	Imagery and Geospatial Community
INTs	HUMINT, MASINT, SIGINT
INTEL	Intelligence
IR	Infrared
I&W	Indications and Warning
JASSM	Joint Air to Surface Standoff Missile
JCS	Joint Chiefs of Staff
JIC	Joint Intelligence Center
JIVA	Joint Intelligence Virtual Architecture
JMIP	Joint Military Intelligence Program
JTF	Joint Task Force
JV 2010	Joint Vision 2010
JWE	Joint Warfighting Experiment
M&S	Modeling & Simulation
MAGTF	Marine Air Ground Task Force
MASINT	Measurement and Signature Intelligence
NASA	National Aeronautical and Space Agency
NFIP	National Foreign Intelligence Program
NIMA	National Imagery and Mapping Agency
NIIRS	Image Quality Metric
NIST	National Intelligence Support Team
NPIC	National Photographic Intelligence Center
NOAA	National Oceanic & Atmospheric Administration
NOS	National Ocean Service
NRO	National Reconnaissance Office
NSA	National Security Agency
NTC	National Training Center
NMJIC	National Military Joint Intelligence Center
OPFOR	Opposing Force
PL	Public Law
PDD	Presidential Decision Directive
PVN	Private Virtual Network
SAR	Synthetic Aperture Radar
SATCOM	Satellite Communications
SECDEF	Secretary of Defense

SDR	Satellite Data Record
SIGINT	Signals Intelligence
SIOP	Single Integrated Operations Plan
TEC	Topographic Engineering Center
TIARA	Tactical Intelligence and Related Activities
TERCOM	Terrain Contour Matching
TLE	Target Location Error
TPED	Tasking, Processing, Exploitation, Dissemination
UAV	Unmanned Air Vehicles
USG	United States Government
USGS	U.S. Geological Survey
USIGS	U.S. Imagery and Geospatial Information System (system being developed by NIMA)
USSTRATCOM	United States Strategic Command